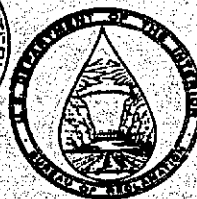UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL CALIBRATION AND
COMPUTER ANALYSIS OF TRAPEZOIDAL TIMBER
CONTROL CHECK WEIRS - FARWELL MAIN
CANAL, NEBRASKA - OCCS PROGRAM

Report No. HYD-583

HYDRAULICS BRANCH
DIVISION OF RESEARCH

OFFICE OF CHIEF ENGINEER
DENVER, COLORADO

AUGUST 1968

Where approximate or nominal English units are used to express a
value or range of values, the converted metric units in parentheses
are also approximate or nominal. Where precise English units are
used, the converted metric units are expressed as equally significant
values. A table of conversion factors--BRITISH TO METRIC UNITS
OF MEASUREMENT--is provided at the end of this report.

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HYDRAULIC MODEL CALIBRATION AND COMPUTER ANALYSIS OF TRAPEZOIDAL TIMBER CONTROL CHECK WEIRS - FARWELL MAIN CANAL, NEBRASKA - OCCS PROGRAM

by

E. R. Zeigler

August 1968

HYDRAULICS BRANCH
DIVISION OF RESEARCH

ACKNOWLEDGMENT

CONTENTS

CONTENTS - Continued

ABSTRACT

Three differently shaped trapezoidal weirs were calibrated in the hydraulic laboratory for free flow and submerged flow canal discharge measurements in field canals of 50- and 90-cfs designed capacity. The 3 weirs were calibrated in the same test facility using model scales of 1:5, 1:2.67, and 1:2.33. In each case the canal bottom upstream from the weir was flush with the weir invert and the downstream canal bottom had a 1.5- to 3-ft vertical drop at the weir. An electronic digital computer was used to make a least squares fit of the calibration data to a curve. Second degree polynomial equations were derived describing free flow conditions and general conical equations describing submerged flow conditions. The computer was used to obtain weir discharge tables and information for weir discharge graphs for submerged conditions. Discharge tables and graphs for each weir and drawings and photographs of model and prototype weir structures are included in the report.

DESCRIPTORS--/ open channel flow/ turbulent flow/ *sharp crested weirs/ subcritical flow/ hydraulic models/ model tests/ *discharge measurement/ *submerged weirs/ curve fitting/ calibrations/ check structures/ weirs
IDENTIFIERS--/ *trapezoidal weirs/ least squares method

SUMMARY

Hydraulic model tests were made to calibrate three timber
control checks used to make canal discharge measurements.
The checks are located on the Farwell Main Canal near
Farwell, Nebraska. The design canal discharges were 50 cfs
(1.41 cms) (cubic meters per second) for two of the weirs
and 90 cfs (2.55 cms) for the other. Each control check
had a different shaped trapezoidal weir notch. The weir
invert was level with the upstream canal bottom but there
was a 1.5- to 3-foot (0.46- to 0.91-meter) vertical drop
at the weir in the downstream canal bottom. Each weir was
calibrated for free flow and submerged flow operating condi-
tions. In the free flow hydraulic model tests, measure-
ments were made of the weir discharge and the upstream
water depth. The model data were plotted in graph form
and a free flow discharge equation was obtained. The
discharge equation was a second degree polynomial of the
form $Q = a + bD + cD^2$, where Q is the weir discharge and
D is the upstream water depth. In the submerged flow
model tests measurements were made of the weir discharge,
upstream water depth, and the downstream water depth.
The submerged flow model data were plotted on a graph in
dimensionless form. Y was the discharge ratio of sub-
merged flow, Q_s, to free flow discharge Q and X was the
submergence ratio of downstream depth Dd to upstream depth
Du. A conical equation of the form $AX^2 + BXY + Y^2 + CX +
DY + E = 0$ gave an excellent fit to the data points. Values
for the coefficients in the free flow and submerged flow
equations were obtained by using the method of least squares
and an electronic digital computer. The computer also was
used for printing discharge tables and discharge graphs for
each weir.

APPLICATIONS

The discharge curves and tables included in this report
can be used to determine the canal discharge passing through
the three tractive force test reaches located on the Farwell
Main Canal near Farwell, Nebraska. They could also be used
for determining discharge through weirs made to the same
dimensions and installed in other canals of similar size.

The methods used in this report are recommended to determine discharge curves and tables for trapezoidal notched weirs of shapes other than those included here.

INTRODUCTION

Three tractive force test reaches were constructed on the Farwell Main Canal near Farwell, Nebraska, Figure 1. At the end of each test reach a timber control check structure was built to provide the designed water flow conditions through the test reaches. During the course of the studies the timber checks with trapezoidal notched weirs will be used as canal discharge measuring devices. Hydraulic model tests were made to calibrate the three weirs for free flow and submerged flow conditions. Handbooks do not contain usable information of this type.

THE INVESTIGATION

Description of the Timber Control Check Installations

The timber control checks are located at Stations 1335+67, 1430+08, and 1459+90 on the Farwell Main Canal. Design canal discharge at Station 1335+67 is 90 cubic feet per second (cfs) (2.55 cms) and 50 cfs (1.41 cms) at Stations 1430+08 and 1459+90. Each timber check has a trapezoidal weir opening. The bottom widths and side slopes are different for each weir. The weir blades were made from galvanized steel strips and bolted to the timber structures. The top edge of the bottom weir blade, defined as the weir invert, is on the same level as the upstream canal bottom. Immediately downstream from the weir invert there is a 1.5- to 3-foot (0.46 to 0.91 meters) drop in the canal bottom. To prevent erosion an 18-inch (46-centimeter) thick layer of riprap is placed over 6 inches (15 centimeters) of bedding for a distance of 10 feet (3 meters) downstream from the weir. Photographs of the three structures are shown in Figure 2, and drawings of the timber structures are shown in Figures 3 and 4. Table 1 lists important weir and upstream canal dimensions.

Figure 5 is a drawing of the permanent measuring wells placed upstream from the timber control checks. Inlet pipes, from the measuring wells to the canal, are located 15.0 feet (4.57 meters) upstream from the checks. The lower inlet pipe is 0.7 to 0.8 foot (0.21 to 0.24 meter)

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above the invert. A water stage recorder, covered by a
permanent shelter, is mounted over each well to measure
and record the upstream water depth above the weir invert.
A staff gage, marked in hundredths of a foot, is installed
near the inlet pipes. The zero elevation of the staff
gage was set at the same elevation as the weir invert.
During canal operation the water stage recorder is peri-
odically checked and the water stage recorder reading is
referenced to the staff gage.

Temporary water stage recorders were installed for measur-
ing the downstream water depth above the weir inverts
during submerged flow operation. Fifty-five-gallon steel
drums with 1-inch (2.5-centimeter) holes in the sides
were placed in the canal downstream from the timber checks
for use as stilling wells.   The water stage recorders were
mounted on the steel drums to record the water level inside
the drums.   Figure 8 shows one of the temporary water stage
recorder installations.

The Model

Drawings and photographs of the hydraulic model are shown
in Figure 6.   The main parts of the model were a head box,
trapezoidal channel, and an outlet box.   The model was
constructed of wood. The interior of the head box, trape-
zoidal channel, and outlet box were lined with galvanized
sheet metal, and the sheet metal joints were soldered to
make the model watertight.

Two vertical pumps connected to two 8-inch (20-centimeter)
pipelines supplied water to the head box.   Each pipeline
had a calibrated, portable venturi orifice meter for
measuring water inflow into the model. A 0.3-foot (9-centi-
meter) thick rock baffle containing 3/4-inch to 1-1/2-inch
(1.9- to 3.8-cm) gravel was installed in the head box and
downstream from the inlet pipes. The baffle reduced the
turbulence from the inlet pipes and provided relatively
calm and uniform inflow into the trapezoidal channel.

The upstream edge of the trapezoidal channel had a rounded
transition to improve the entrance flow condition, Figure 6.
The transition was a 90° arc with a 1-foot (30-centimeter)
radius.   The trapezoidal model channel was 3 feet (91 centi-
meters) wide, 1-1/2 feet (46 centimeters) deep, 20 feet
(6.1 meters) long, and had 1 vertical to 1-1/2 horizontal
side slopes.

Model weirs were attached to the upstream bulkhead of the
outlet box. The model weirs were constructed of plywood
and the weir blades were made from 0.11-inch (0.28-centimeter)
thick metal strips. When installing the weirs in the model,
the top of the bottom weir blade was placed flush with the
trapezoidal channel bottom. Tailwater elevations in the out-
let box (submergence of the weir) were controlled with an
adjustable hinged gate located at the downstream end of the
outlet box.

Figures 7, 8, and 9 show photographs of comparable dis-
charges in the three model and prototype weirs.

Model Tests

Three different sizes of trapezoidal weirs were tested in
the hydraulic model. The same model was used so it was
necessary to test each weir using a different model scale.
The model scales were as follows:

    Weir at Station 1335+67 - Scale 1:5
    Weir at Station 1430+08 - Scale 1:2.67
    Weir at Station 1459+90 - Scale 1:2.33.

Topography simulating the prototype was constructed in the
outlet box for the weir at Station 1459+90. The topography
extended 24 feet (7.3 meters), prototype distance, down-
stream from the weir. Riprap was placed for a distance of
10 feet (3 meters). An additional 14 feet (4.26 meters) of
canal extended downstream, Figure 10. Hydraulic model tests
were made with and without topography in the model. A
comparison of these test results showed that the topography
was not needed to obtain satisfactory hydraulic data. No
topography was constructed for the weirs at Stations 1335+67
and 1430+08. The water flowed directly from the weirs into
the outlet box.

Free flow and submerged tests were made on each of the three
weirs. In the free flow tests the weir nappe was aerated -
the weir nappe, or jet of water flowing from the weir open-
ing, was completely surrounded by the atmosphere. In the
submerged flow tests the tailwater elevation was above the
bottom of the weir invert - part of the nappe above the
weir invert was submerged.

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In this report the upstream depth and the downstream water depth (for submerged flow tests) is the depth of water measured above the weir invert.

In making the free flow tests the measured model discharge was increased in increments and the upstream water depth was measured for each discharge.

In making a submerged flow test the measured model discharge was held constant and the tailwater was raised in increments; both upstream and downstream water depths were measured. To make additional submerged flow tests, the measured model discharge was increased and the effect of the downstream depth on the upstream depth was measured.

The upstream water depth was measured at the centerline of the trapezoidal channel and 15 feet (4.57 meters), prototype distance, upstream from the weirs. Upstream depth measurements were made with a point gage mounted on an aluminum U-channel that spanned the canal. The downstream water depth was measured with a hook gage, mounted in a stilling well made from a 6-inch (15-centimeter) diameter plastic pipe. A flexible hydraulic tube led from the stilling well to a static pressure probe that was placed in the outlet box. The downstream water depth was therefore measured at the location of the static pressure probe. The probe was placed 1/2-foot (0.15-meter) downstream from the weir and 1 foot (0.3 meter) from the side of the outlet box for model tests made for weirs at Stations 1335+67 and 1430+08, Figures 7 and 8. For model tests with the weir at Station 1459+90 the downstream water depth was measured at a line 18.3 feet (5.58 meters) downstream from the weir, and at the canal centerline.

DISCUSSION AND RESULTS OF THE INVESTIGATION

Free Flow Tests

The first part of the model study consisted of calibrating the three weirs under free flow conditions. The 1-1/2-foot (46-centimeter) model depth allowed testing of prototype depths larger than normal design canal and weir depths shown in Figures 3 and 4. The weirs were calibrated for discharges larger than design discharges. For each weir the upstream water depth was measured at many different discharges. The depth versus discharge data for the three weirs is plotted on Figure 11.

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A second degree polynomial equation was used to describe
the mathematical relationship between the variables, weir
discharge and upstream canal water depth. The general
free flow discharge equation for the three weirs, with
discharge Q taken as the dependent variable and depth D
the independent variable, is as follows:

(1) $Q = a + bD + cD^2$,

where

   Q represents weir discharge, cubic feet per second,

   D represents the water depth in feet above the weir
      invert at a point 15.0 feet (4.57 meters) upstream
      from the weir,

   a, b, and c are coefficients.

For each weir the coefficients a, b, and c, have specific
values in the free flow equation. The method of least
squares was used to determine values of the coefficients
for each weir, see Appendix A. The free flow discharge
equations are

   (2)   Station 1335+67 $Q = 2.453 + (0.060)D + (3.529)D^2$
                                    for D = 1.0 to 7.0 feet
                                    (0.3 to 2.1 meters)

   (3)   Station 1430+08 $Q = 1.396 - (0.268)D + (7.981)D^2$
                                      for D = 0.5 to 3.6 feet
                                    (0.15 to 1.1 meters)

   (4)   Station 1459+90 $Q = 1.247 - (0.434)D + (14.105)D^2$
                                      for D = 0.5 to 2.3 feet
                                    (0.15 to 0.70 meters)

Graphs of the three equations are shown in Figure 11.

Submerged Flow Tests

Calibrating the weirs for submerged conditions was more
difficult than for free flow conditions. In free flow
tests the upstream water depth controls the weir discharge,
but in submerged flow tests both the upstream and down-
stream water depths control the discharge. The hydraulic

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model data for the submerged trapezoidal weir tests were
plotted in the form, Discharge Ratio versus Submergence
Ratio, where the

Submergence ratio = Dd/Du

Discharge ratio = Qs/Q

and

Dd = downstream water depth above the weir invert,

Du = upstream water depth above the weir invert,

Qs = weir discharge for the given upstream and down-
stream water depths (submerged discharge),

Q = free flow weir discharge for the given upstream
water depth (unsubmerged or free flow discharge).

Data taken from the hydraulic model submerged weir tests
included upstream water depth (Du), downstream water depth
(Dd), and the model discharge or submerged discharge (Qs).
The free discharge (Q) was computed using the upstream
depth (Du) in the free flow discharge equation. Both the
discharge ratio and submergence ratio were then computed
and the data points plotted. Figure 12 is a graph of the
data points for the weir at Station 1335+67, Figure 13 -
Station 1430+08, and Figure 14 - Station 1459+90. In each
figure the discharge ratio is the ordinate and the sub-
mergence ratio is the abscissa.

The alinement of the data points on the three graphs in-
dicates the relationship of the discharge ratio to the
submergence ratio. However, a mathematical formula de-
scribing the discharge ratio in terms of the submergence
ratio was needed. By inspection, an ellipse was found to
fit the shape of the curve formed by the plotted data
points on the graphs. The major axis of the ellipse was
rotated 45° to the X axis of the graph. However, the
elliptical curve did not fit the entire central portion
of the plotted points. But the general equation of the
curve was used in making a least squares fit for the data
points.

The general equation of an ellipse with a rotated axis is

(5) $ax^2 + bxy + cy^2 + dx + ey + f = 0,$

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where x and y are variables. The coefficients a, b, c, d, e, and f have specific values for any given ellipse. By dividing every term in the above equation by c, renaming the coefficients by using upper case letters and rearranging the terms, the equation takes the form

$$(6) \quad Ax^2 + Bxy + y^2 + Cx + Dy + E = 0$$

or

$$(7) \quad y^2 + (Bx + D)y + (Ax^2 + Cx + E) = 0.$$

If the value of x is known then the equation is a quadratic equation in y. Positive values only for the discriminant are used because we are interested in the plot in the first quadrant, and

$$(8) \quad y = \frac{-(Bx + D) + \sqrt{(Bx + D)^2 - 4(Ax^2 + Cx + E)}}{2}$$

To use this equation for the case of submerged flow we will let

   y = discharge ratio,

   x = submergence ratio,

for $0 \le x \le 0.98$. For x = 1.0 there would be zero head across the weir.

The method of least squares described in Appendix B was used to find the specific values of the coefficients A, B, C, D, and E for each discharge ratio – submergence ratio formula. The values of the coefficients are listed in the following table:

Weir at Station	A	B	C	D	E
1335+67	1.063	-1.652	1.685	1.806	-2.802
1430+08	1.031	-1.755	1.739	1.828	-2.797
1459+90	1.021	-1.918	1.778	1.837	-2.788

The graphs of the discharge ratio – submergence ratio formula for the weirs are shown on Figures 12, 13, and 14.

Description and Use of the Weir Discharge Graphs and Discharge Tables

Figures 15, 16, and 17 are graphs of the weir discharge for submerged flow conditions, Figure 15 - Station 1335+67, Figure 16 - Station 1430+08, and Figure 17 - Station 1459+90. The graph ordinate is the upstream water depth above the weir invert, the abscissa is the weir discharge, and lines representing constant downstream water depths are drawn on the graph.

An X-Y plotter which operates from punched cards was used to draw the curves of Figures 15, 16, and 17. Information in the form of approximately 1,000 data cards per graph was supplied to the plotter. A program was written for an electronic digital computer to compute and punch the information on the data cards. The discharge ratio - submergence ratio formula and free flow equation were used in making data card computations for the discharge graphs in Figures 15, 16, and 17.

To find the weir discharge both the upstream and downstream water depths above the weir invert must be known. For an example illustrating the use of the graph consider an up-stream water depth of 2.12 feet (0.65 meter), a downstream water depth of 1.53 feet (0.47 meter), and use Figure 17. Find the 2.12-foot (0.65-meter) upstream depth value on the Upstream Depth scale at the left edge of the graph. Follow the 2.12-foot upstream depth line horizontally right to the appropriate line of downstream water depth. In this example one has to interpolate between the 1.5- and 1.6-foot constant downstream depth lines to find the 1.53-foot (0.47-meter) downstream water depth. At the point where the 1.53-foot (0.47-meter) downstream depth crosses the 2.12-foot (0.65-meter) horizontal upstream depth line follow the discharge line vertically downwards to the Weir Discharge scale at the bottom of the graph. The weir discharge is 49.8 cfs (1.41 cms).

A program was written for an electronic digital computer to calculate and print the weir discharges for the range of upstream and downstream water depths. The discharge ratio - submergence ratio formula and free flow equation were used in making the weir discharge calculations. Weir discharge tables are in Appendixes: Station 1335+67 - Appendix D, Station 1430+08 - Appendix E, and Station

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1459+90 - Appendix F. The vertical column at the left edge of each table is the upstream water depths, Du. The top horizontal row of the table is the downstream water depths, Dd, and the columns of numbers below the downstream water depths are the weir discharges for the given upstream and downstream water depths.

An example is given for using the weir discharge tables. Use the table in Appendix F, upstream water depth (Du) of 2.32 feet (0.71 meter), and downstream water depth (Dd) of 1.9 feet (0.58 meter). Select the page of the table that has the range of upstream and downstream water depths that include Du = 2.32 feet and Dd = 1.9 feet. In the column marked Du find the 2.32 water depth. The row of numbers horizontally to the right of 2.32 are weir discharges for Du = 2.32 feet and for the downstream water depths listed at the top of the table. For Dd = 1.9 feet (0.58 meter) the weir discharge is 52.0 cfs (1.47 cms).

T A B L E I

WEIR AND CANAL DIMENSIONS
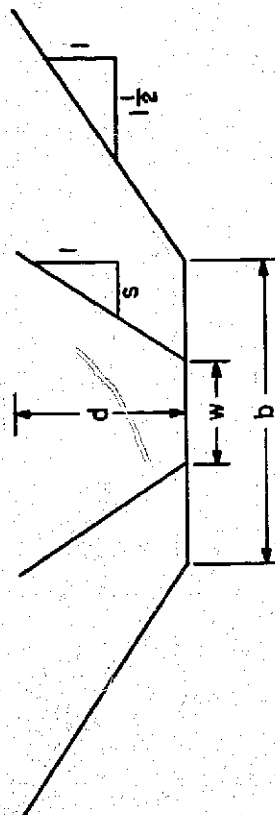
WEIR AT STATION	CANAL BOTTOM WIDTH FEET (b)	WEIR BOTTOM WIDTH FEET (w)	WEIR DEPTH FEET (d)	WEIR SIDE SLOPES (s)	CANAL DESIGN DISCHARGE cfs
1335+67	15	1.417	5.58	0.292	90
1430+08	8	2.167	3.33	0.771	50
1459+90	7	3.146	3.08	1.333	50

FIGURE 1
REPORT HYD-583
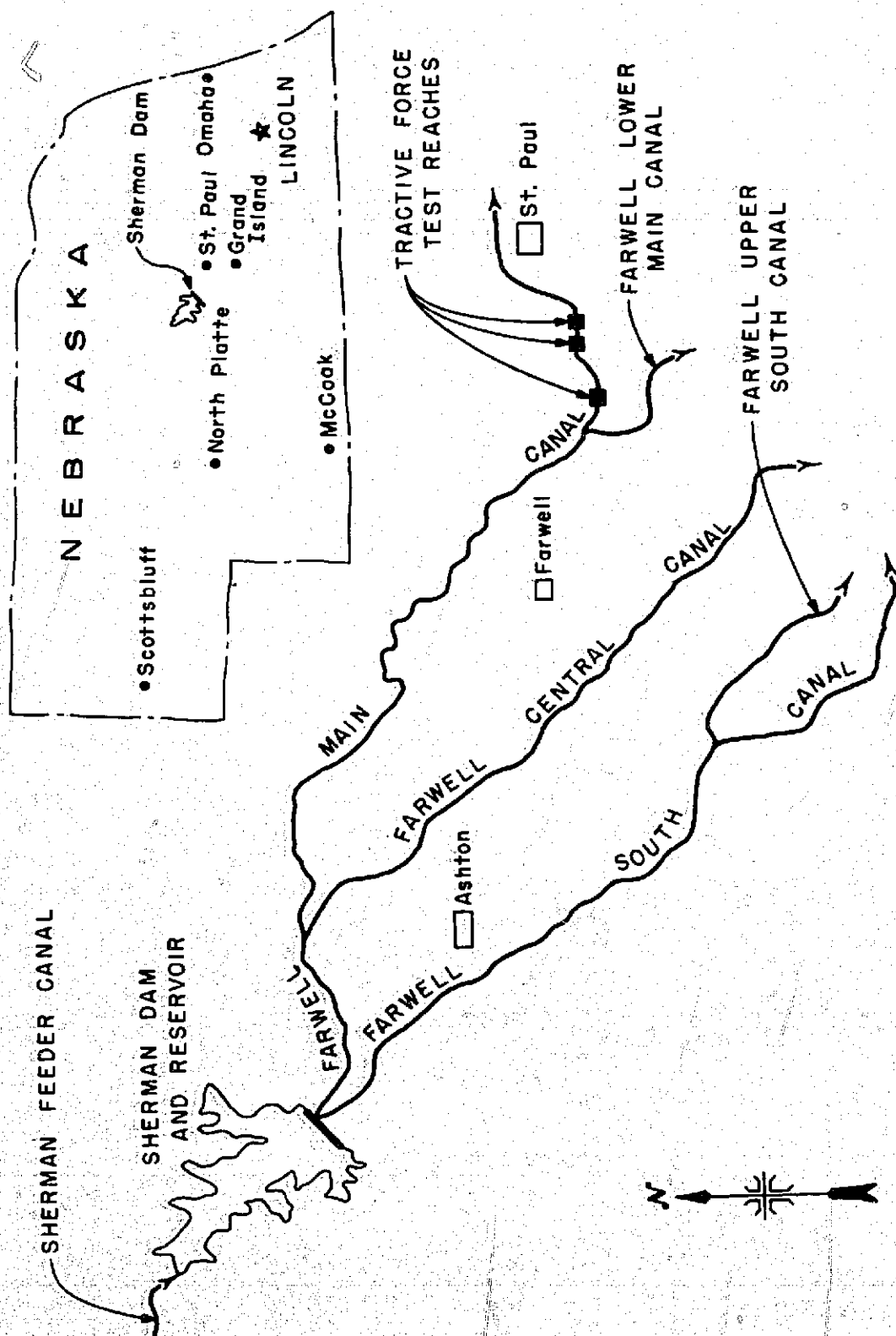
LOCATION MAP

Figure 2
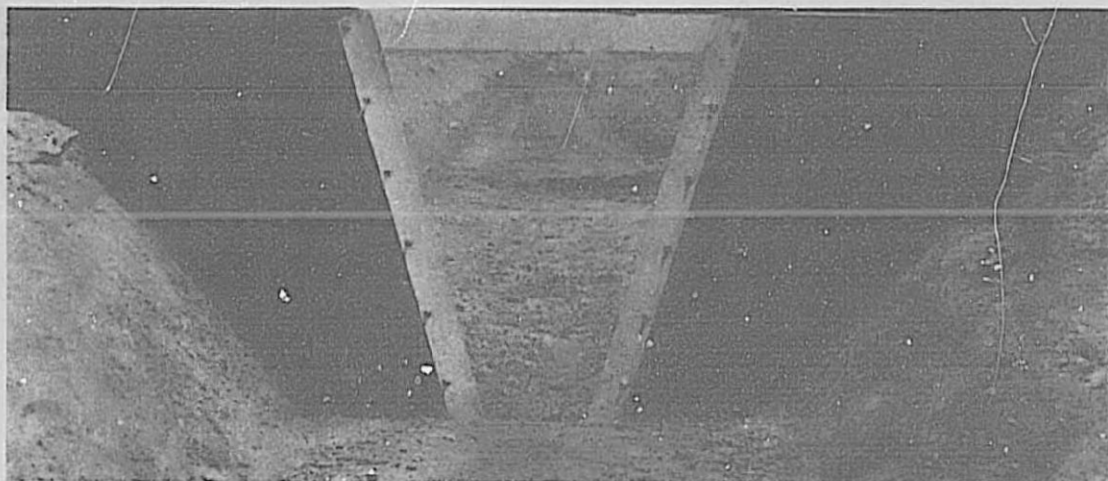
Station 1335+67   Photo P707-729-2748

Station 1430+08   Photo P707-729-2724

Station 1459+90   Photo P707-729-2704
Timber Control Checks - Upstream Views

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FIGURE 3
REPORT HYD-583

NOTES

All timber to be treated.
Concrete design based on a compressive strength
of 3000 lbs. per sq. in.

FIGURE 4
REPORT HYD-583

DETAIL A

DETAIL B

SCALE OF FEET

PLAN - STATION 1460+00

FLOW
Symmetrical about
Farwell Main Canal

SECTION D-D

SCALE OF FEET

SECTION E-E

PLAN - STATION 1430+00

FLOW
Symmetrical about
Farwell Main Canal

SECTION A-A

SECTION B-B

NOTE

All timber to be treated.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
MIDDLE LOUP DIVISION-FARWELL UNIT-NEBRASKA
FARWELL MAIN CANAL
STATION 1430+08 AND STATION 1459+90
TIMBER CONTROL CHECKS

707-D-492

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FIGURE 5
REPORT HYD-583

CANAL STA	B	EL.A.	d	L₁	L₂
1335+00	19'-3"	1953.23	4'-11½"	11'-0"	9'-6"
1429+85	12'-3"	1922.94	2'-8¼"	7'-6"	6'-0"
1459+85	11'-0"	1915.61	2'-1½"	5'-9"	5'-3"

NOTE

Concrete design based on a compressive strength of 3000 lbs per sq. in.

DETAIL A

SECTION C-C

SCALE OF INCHES

SECTION B-B

PLAN

SECTION A-A

NOTE: Measuring well may be opposite the hand about canal as directed.

SCALE OF FEET

Figure 6

Left photograph - looking upstream at the outlet box, weir bulkhead, trapezoidal channel, and the inlet box. H-1553-1 NA
Right photograph - looking into the inlet box at the transition on the upstream end of the trapezoidal channel. The rock baffle is shown in the lower right corner of the photograph. H-1553-4 NA
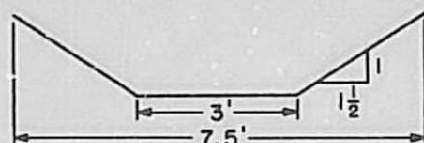
SECTION A-A
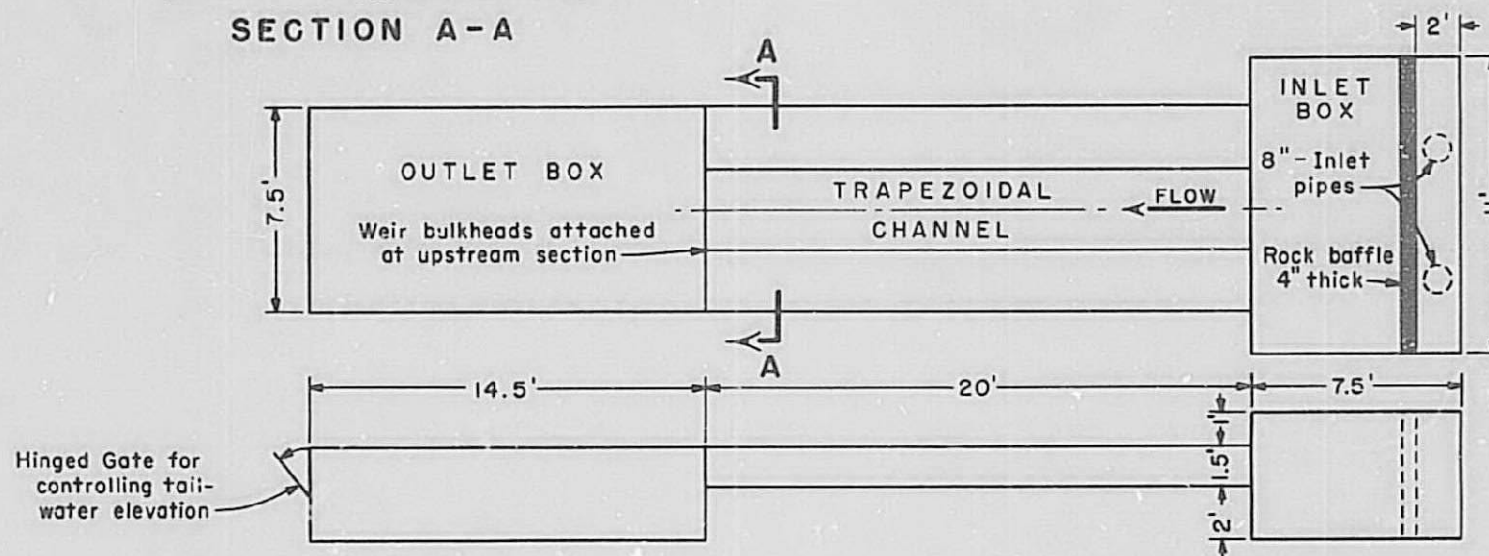
THE HYDRAULIC MODEL

Figure 7
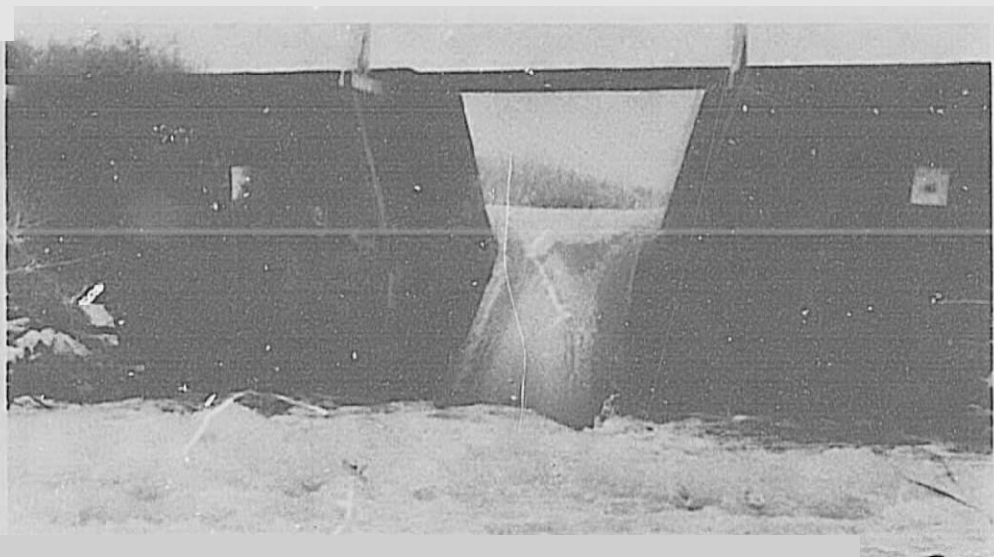
Prototype timber control check at Station 1335+67.
Photo PX-D-61970
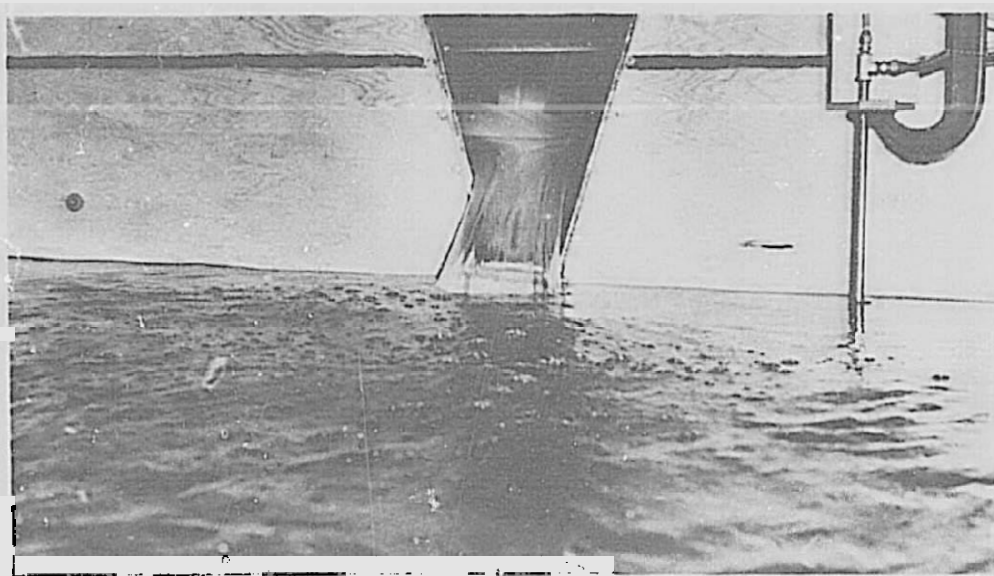
Model at Station 1335+67.   Photo PX-D-61971

The weir discharge is 58 cfs (1.64 cms), the upstream
water depth is 3.95 feet (1.20 meters), the downstream
water depth is 0.4 foot (12.2 centimeters), and the
submergence ratio, Dd/Du, is 0.10. The top of the
black line on the model weir bulkhead (lower photograph)
represents the top of the weir structure in the proto-
type. Also shown in the model photograph (right side)
is the static pressure probe used for measuring the
downstream water depth.

Figure 8
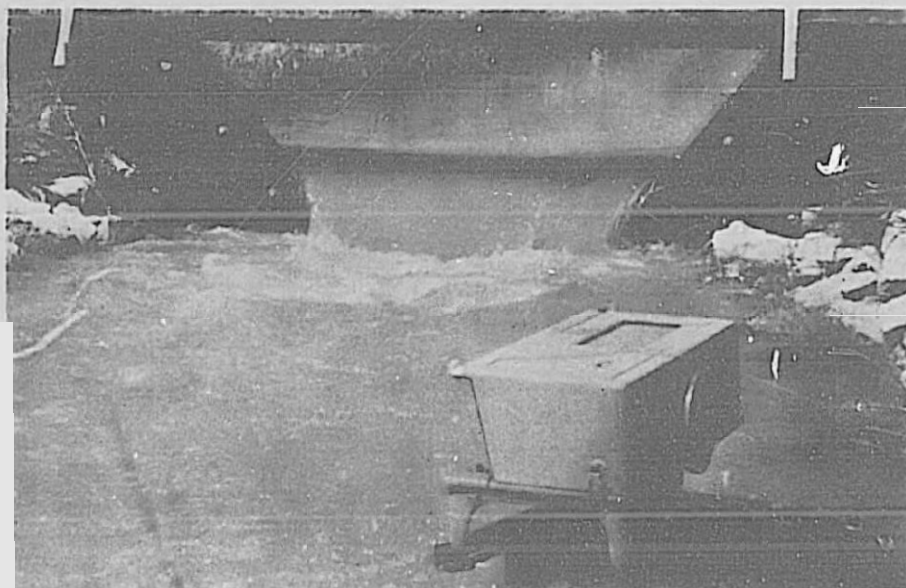
Prototype timber control check at Station 1430+08.
Note the temporary water stage recorder and stilling
well for recording the downstream water surface ele-
vation. Photo PX-D-61972
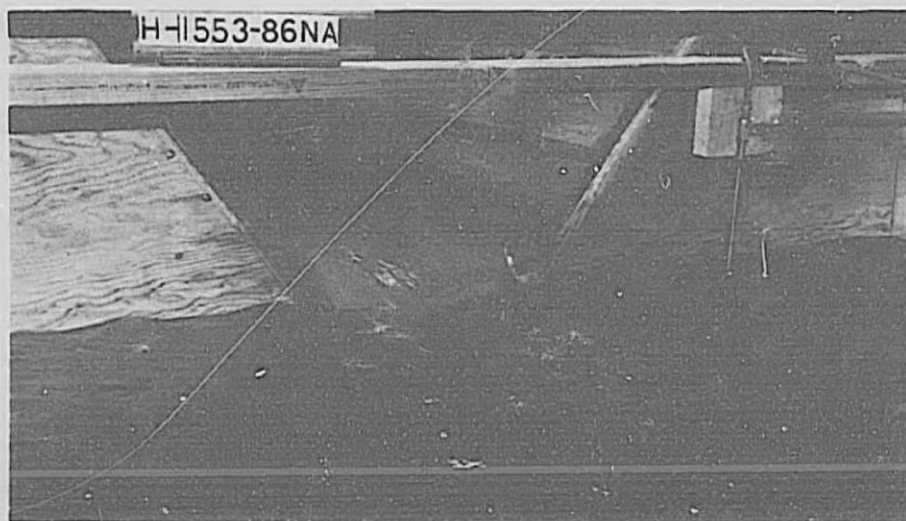
Model at Station 1430+08. Photo PX-D-61973

The weir discharge is 25 cfs (0.71 cms), upstream
water depth is 1.86 feet (0.57 meter), downstream
water depth is 1.05 feet (0.32 meter), and the
submergence ratio, D_d/D_u, is 0.56.

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Figure 9
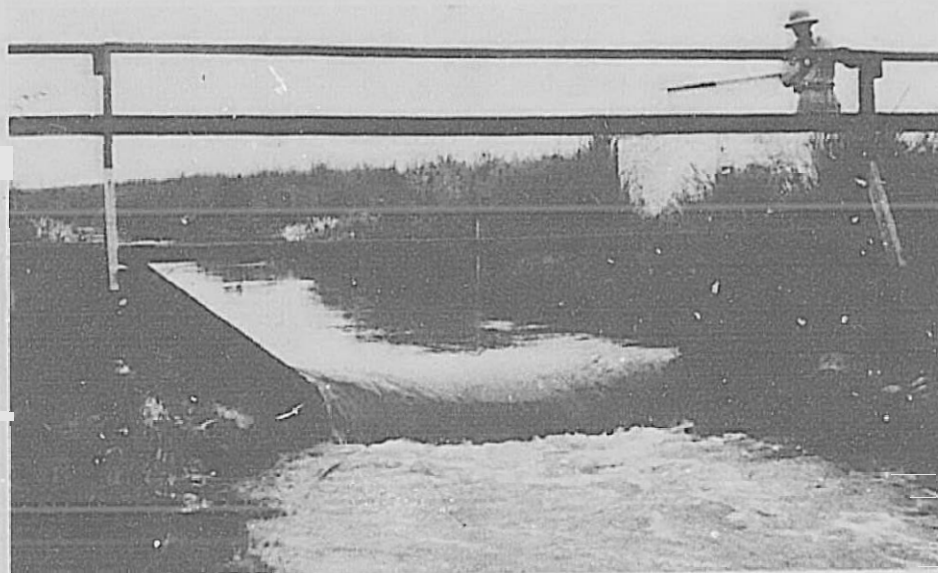
Prototype timber control check at Station 1459+90.
Photo PX-D-61974

Model at Station 1459+90.   Photo PX-D-61975

The weir discharge is 25 cfs (0.71 cms), upstream
water depth is 1.35 feet (0.41 meter), downstream
water depth is 0.45 foot (0.14 meter), and the
submergence ratio, Dd/Du, is 0.33.

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Figure 10

Prototype timber control check at Station 1459+90.
Photo P707-729-2708

Model at Station 1459+90. Photo PX-D-61976

Topography was installed in the model outlet box
downstream from the weir. The mortar area is the
10-foot (3.04-meter) length of riprap placed down-
stream from the prototype weir. The 14-foot (4.27-
meter) additional length of the downstream canal is
built of plywood. The horizontal black line drawn
on the upper part of the model weir bulkhead repre-
sents the top of the prototype weir.

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FIGURE 11
REPORT HYD-583
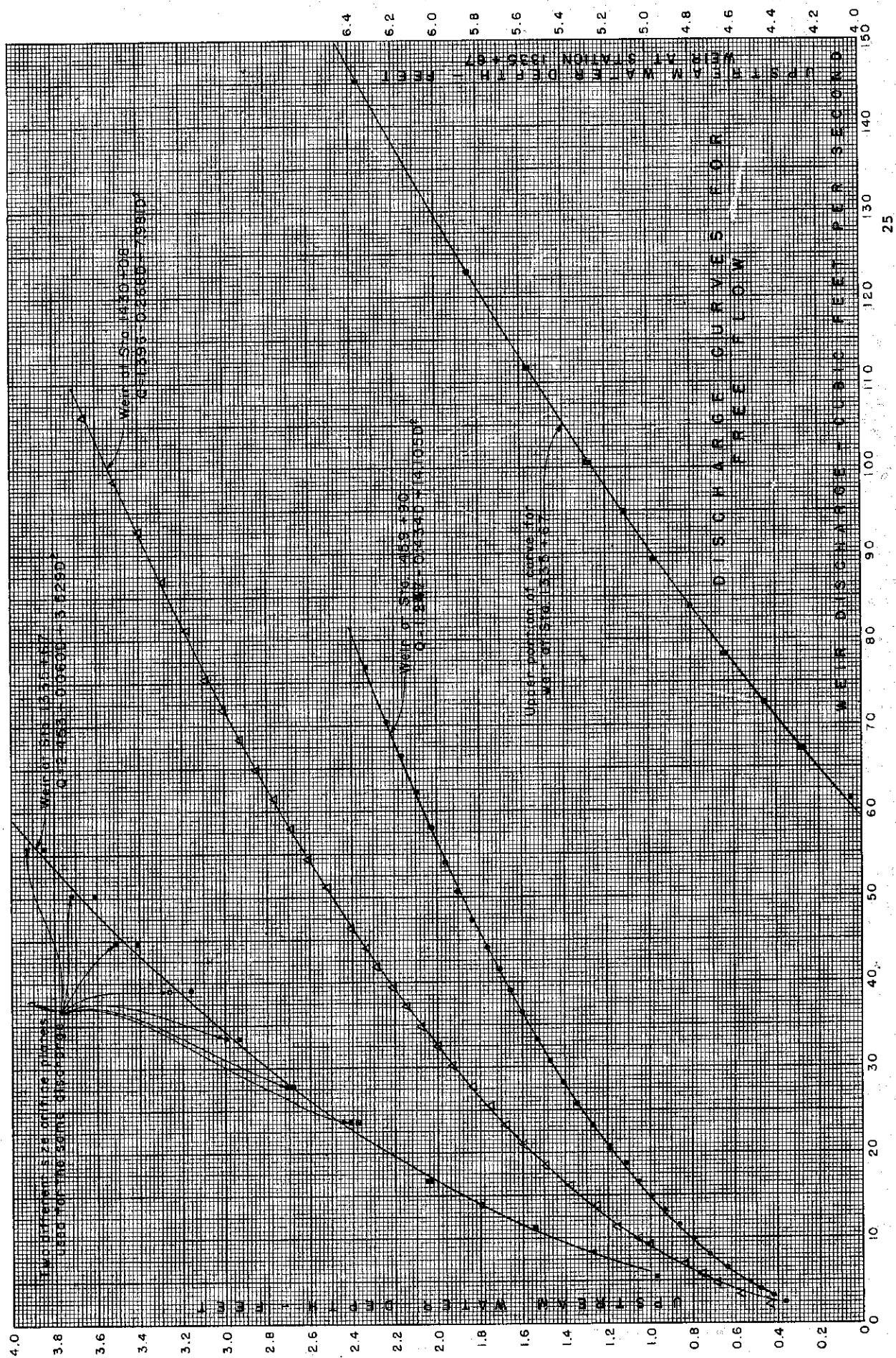
DISCHARGE CURVES FOR FREE FLOW

FIGURE 12
REPORT HYD-583

$$y = \frac{-(1.632x + 1.806) + \sqrt{(1.632x + 1.806)^2 - 4(1.083x^2 + 1.685x - 2.802)}}{2}$$

y - DISCHARGE RATIO $\frac{Q_s}{Q}$

x - SUBMERGENCE RATIO $\frac{D_d}{D_u}$
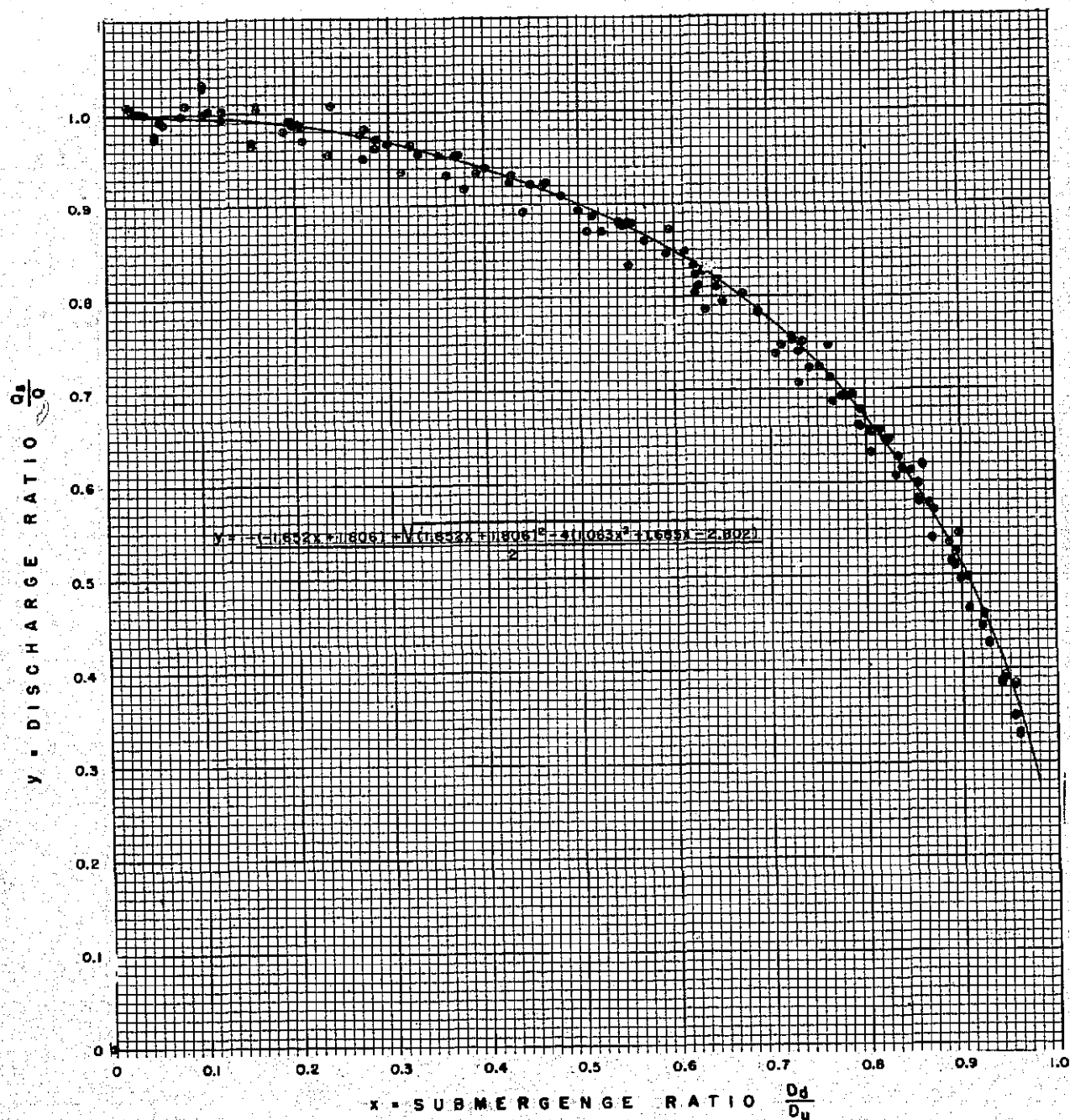
DISCHARGE RATIO - SUBMERGENCE RATIO
FOR WEIR AT STATION 1335 + 67

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FIGURE 13
REPORT HYD-583
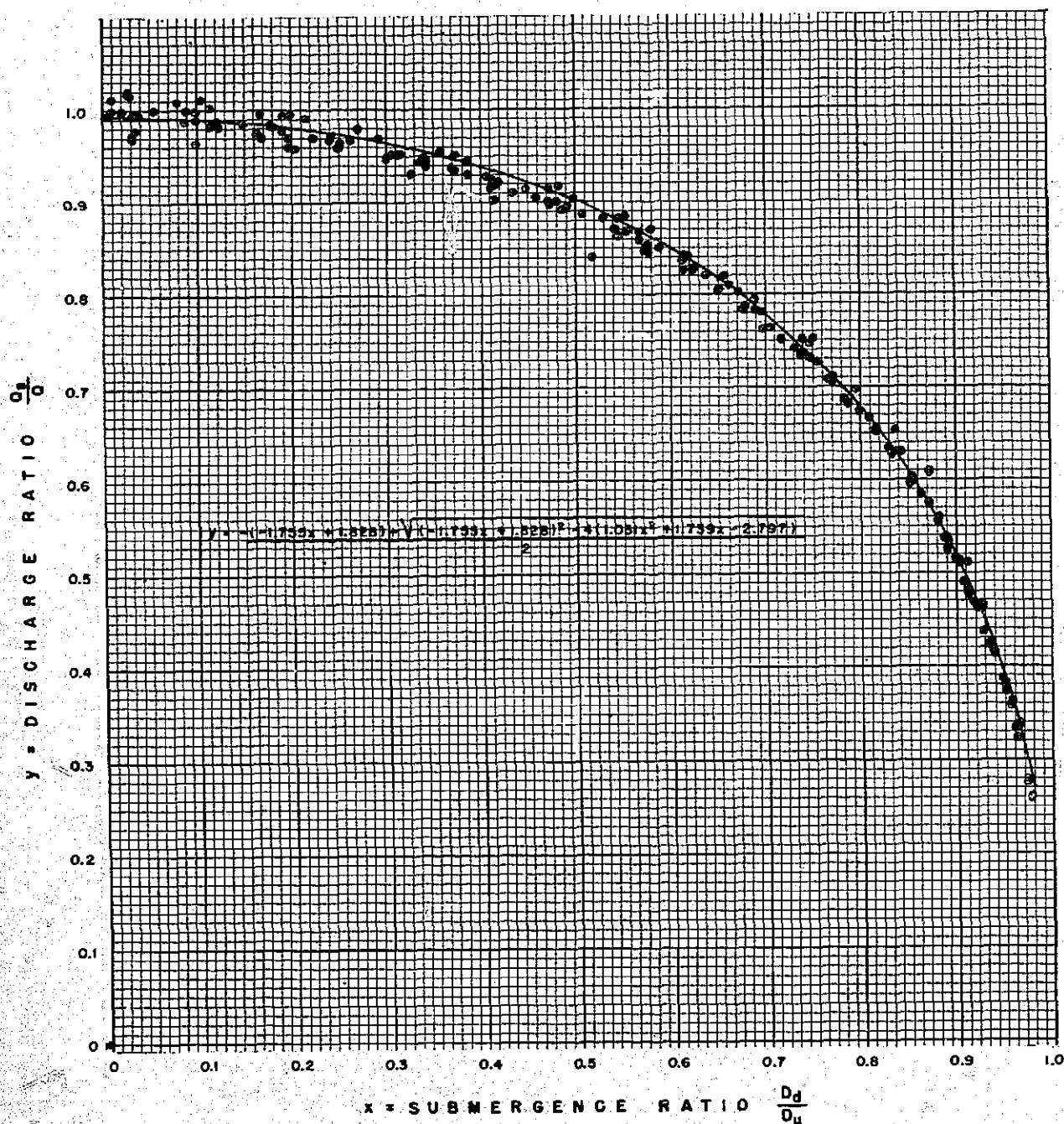
DISCHARGE RATIO — SUBMERGENCE RATIO
FOR WEIR AT STATION 1430 + 08

28

FIGURE 14
REPORT HYD-583

DISCHARGE RATIO — SUBMERGENCE RATIO
FOR WEIR AT STATION 1459 + 90

29
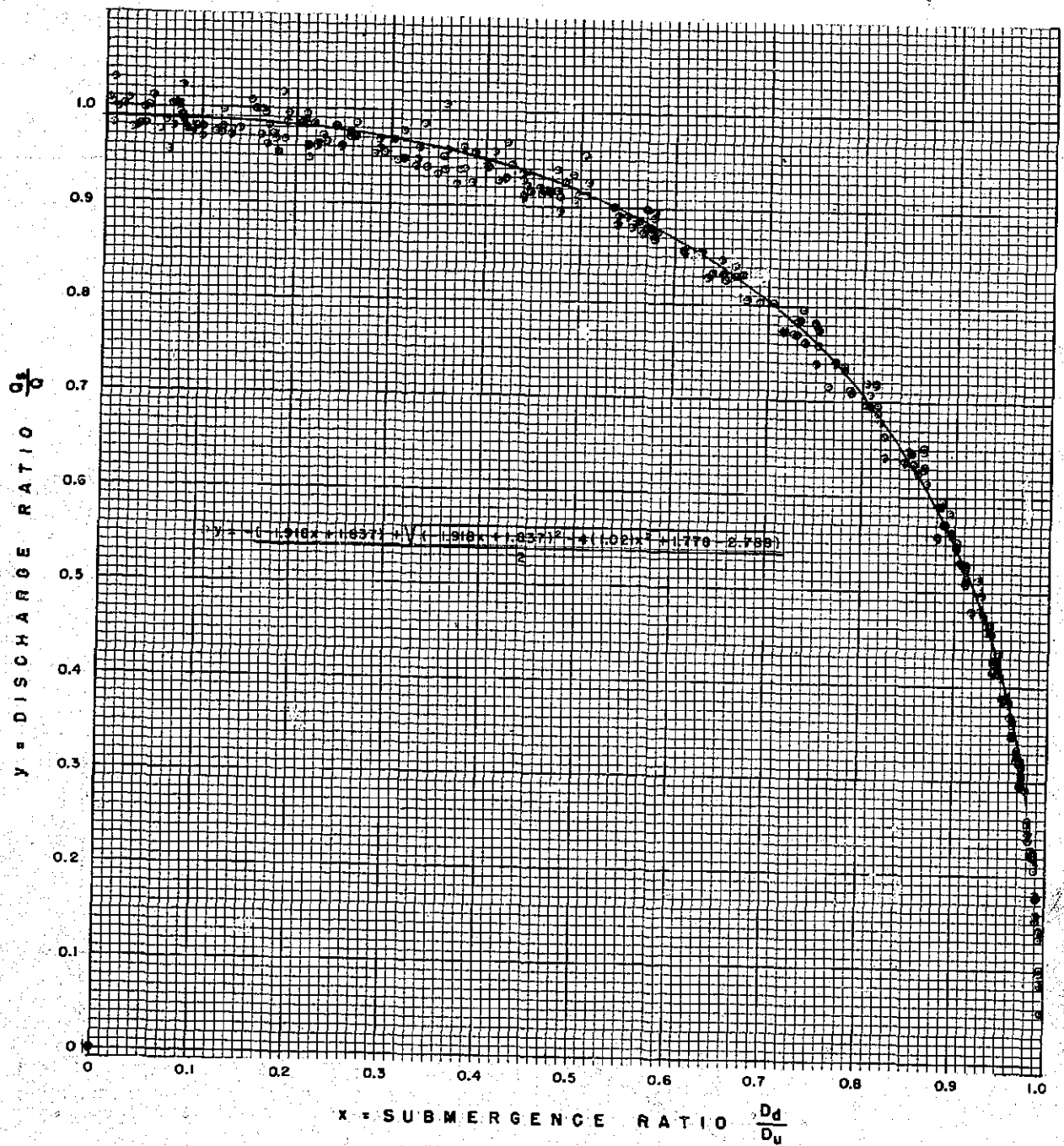
FIGURE 15
REPORT HYD-583
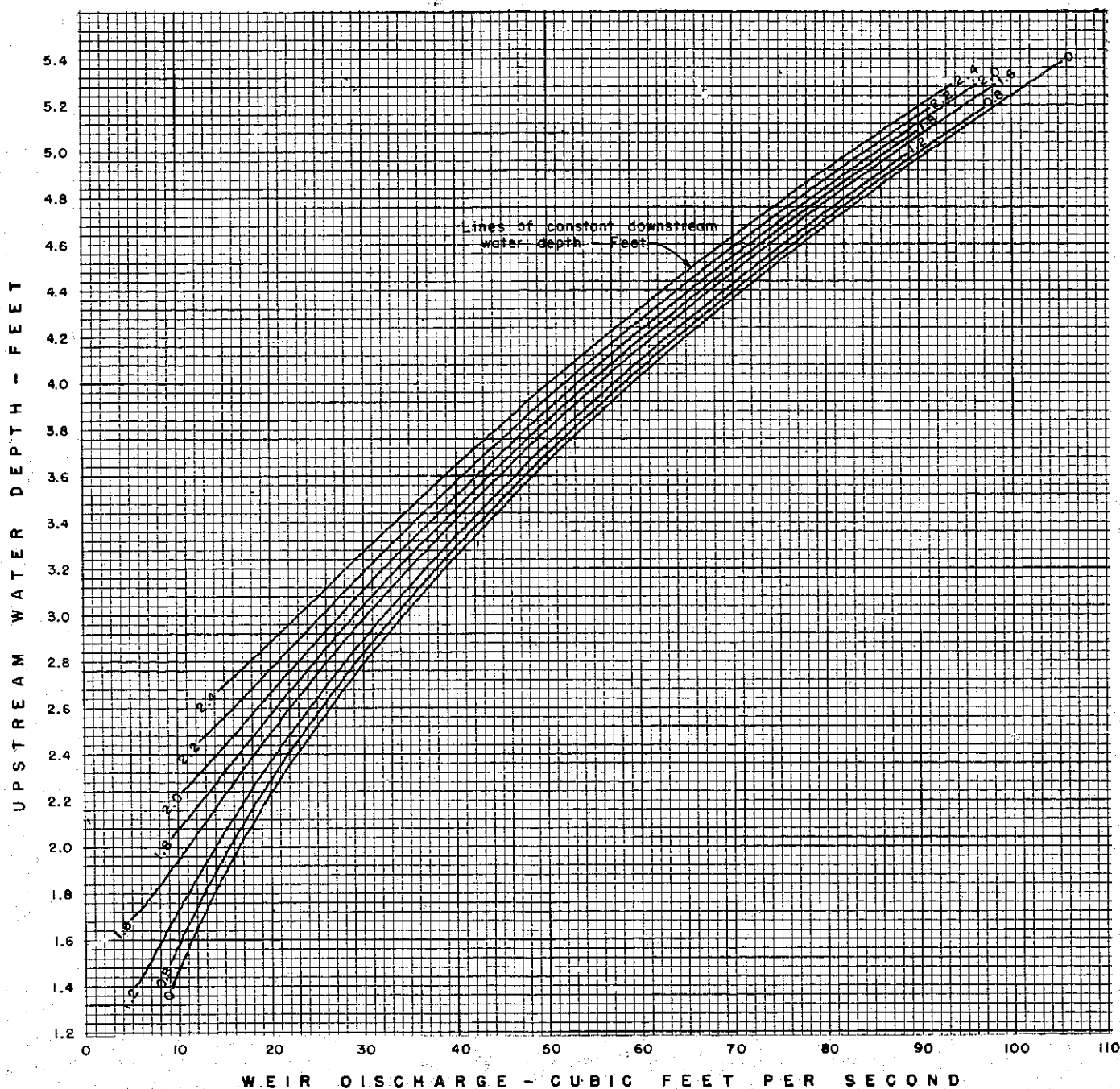
SUBMERGED FLOW DISCHARGE CURVES
FOR WEIR AT STATION 1335 + 67

31

FIGURE 16
REPORT HYD-583

SUBMERGED FLOW DISCHARGE CURVES
FOR WEIR AT STATION 1430+08

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FIGURE 17
REPORT HYD-583

Example: For Upstream Water Depth D_u=2.12, and
Downstream Water Depth D_D=1.53, The
Discharge is 49.8 c.f.s.

Lines of constant
downstream water
depth-feet

UPSTREAM WATER DEPTH - FEET
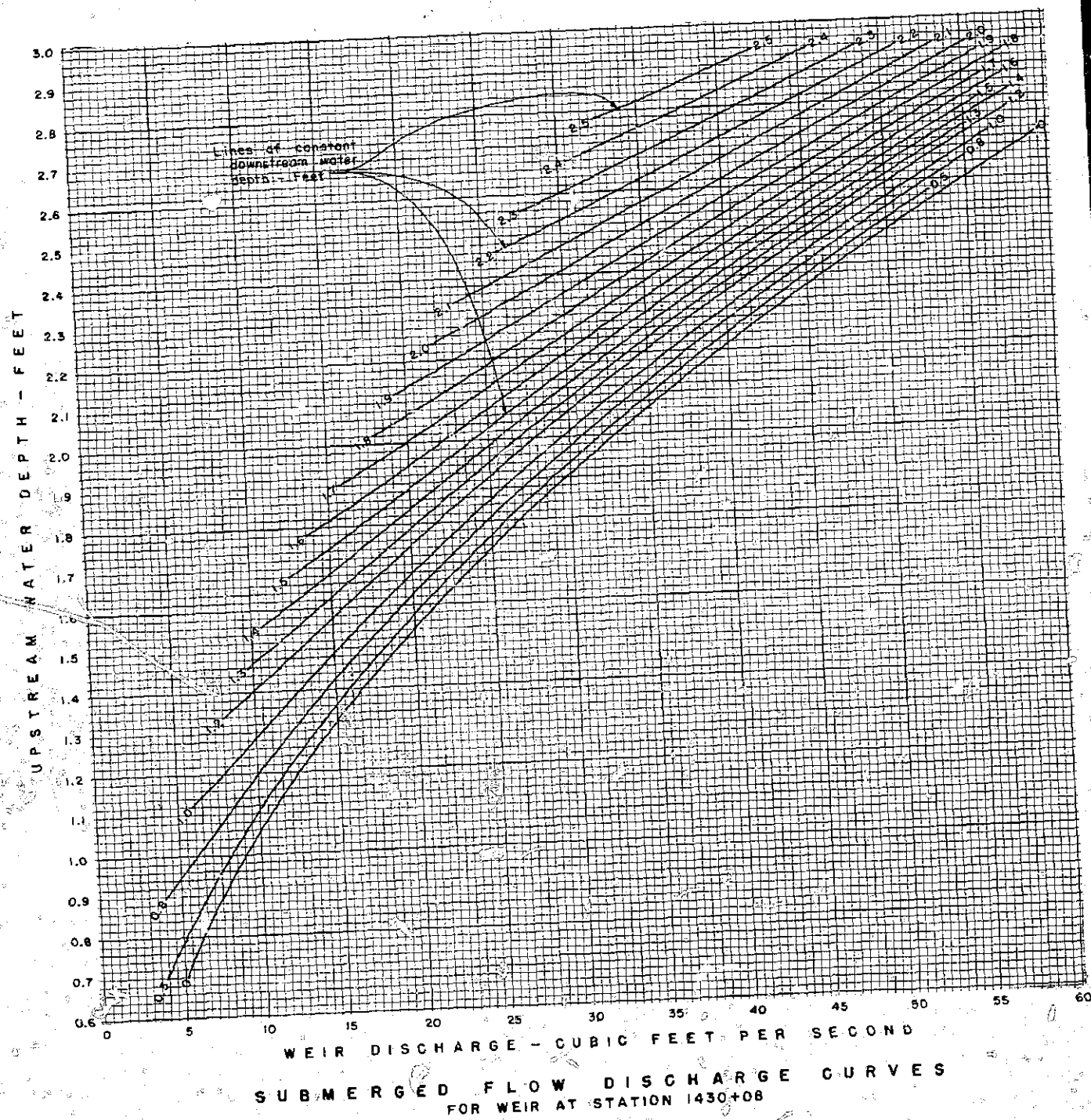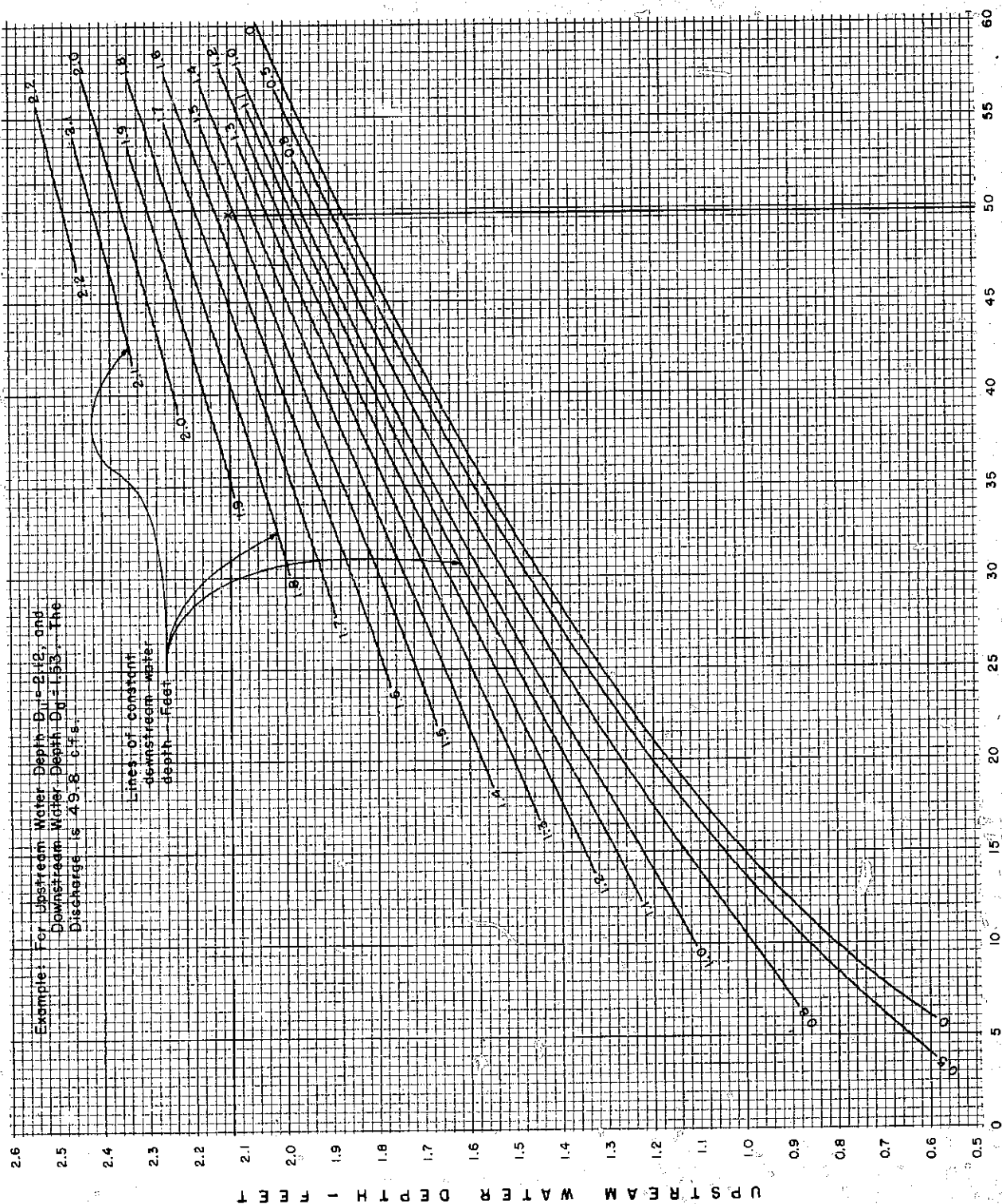
WEIR DISCHARGE - CUBIC FEET PER SECOND

SUBMERGED FLOW DISCHARGE CURVES

FOR WEIR AT STATION 1459 + 90

35

APPENDIX A

Method of Least Squares to Determine Coefficients in the Weir Free Flow Discharge Equation

Measurements were made of the weir discharge (Q) and the upstream water depth (D). The data points (discharge versus water depth) were plotted on the graph in Figure 11. The method of least squares was used to determine values of the coefficients a, b, and c for the second degree polynomial equation

$$Q = a + bD + cD^2.$$

By using the least squares method an equation was obtained which "fits" the data points. Some of the data measurement errors are reduced, or "averaged out."

First consider the data points shown on Figure a, Appendix C. There are n number of data points (Q_1, D_1), (Q_2, D_2), ..., (Q_n, D_n). The solid black points are the actual measured values of Q and D. The curved line represents the desired equation

$$Q = a + bD + cD^2.$$

For point number 1 the value D_1 is substituted into the above equation and the value Q_1' is obtained. The value Q_1' is on the desired curve. The residual of point number 1 is defined as the difference between the value Q_1' and the actual measured value Q_1, which is the vertical distance, from the plotted point to the curve. For any point (Q_i, D_i) the residual (r_i) is

$$r_i = (Q_i - Q_i') = (Q_i - a - bD_i - cD_i^2).$$

The method of least squares determines values for the coefficients a, b, and c so that the sum of the squares of the residuals is a minimum, for all the data points from $i = 1$ to $i = n$

$$\sum_{i=1}^{n} (r_i)^2 = \sum_{i=1}^{n} (Q_i - Q_i')^2 = \text{minimum value.}$$

Let the function G be defined as

$$G = \sum_{i=1}^{n} (Q_i - Q_i')^2.$$

The values Q_i, Q_i', and D_i are known values; therefore, the variables of the function G are the coefficients a, b, and c. If the function is denoted by G(a, b, c), then

$$G(a,b,c) = \sum_{i=1}^{n} (Q_i - Q_i')^2 = \sum_{i=1}^{n} \left[Q_i - a - bD_i - cD_i^2 \right]^2.$$

To obtain the minimum value of the function G(a, b, c), partial derivatives are taken of G(a, b, c), and the derivatives set equal to zero. The derivatives are

$$\frac{\partial G}{\partial a} = \Sigma [2(Q_i - a - bD_i - cD_i^2)(-1)] = 0,$$

$$\frac{\partial G}{\partial b} = \Sigma [2(Q_i - a - bD_i - cD_i^2)(-D_i)] = 0,$$

$$\frac{\partial G}{\partial c} = \Sigma [2(Q_i - a - bD_i - cD_i^2)(-D_i^2)] = 0,$$

where $i = 1$ and n having been dropped from the summation sign (Σ) for convenience. The following three equations are obtained by dividing by 2, multiplying and rearranging terms, and placing the summation sign in each term within the square brackets.

$$an + b\Sigma D_i + c\Sigma D_i^2 = \Sigma Q_i$$

$$a\Sigma D_i + b\Sigma D_i^2 + c\Sigma D_i^3 = \Sigma Q_i D_i$$

$$a\Sigma D_i^2 + b\Sigma D_i^3 + c\Sigma D_i^4 = \Sigma Q_i D_i^2$$

The system of three simultaneous linear equations (in the coefficients) are solved to find the values of a, b, and c.

A computer program was written and an electronic digital computer used to solve for the values a, b, and c for each of the three weirs. The three free flow discharge equations are shown in Figure 11.

APPENDIX B

Method of Least Squares to Determine Coefficients in the Discharge Ratio - Submergence Ratio Equation

Data points of the discharge ratio (y) versus the submergence ratio (x) were plotted on graphs in Figures 12, 13, and 14. By inspection a conic equation of an ellipse was found to define the curve formed by the plotted data points. Approximate values for the coefficients A, B, C, D, and E of the conic equation were determined, but the resulting equation when plotted did not pass through the entire group of plotted data points. Therefore, the least squares method with the aid of Newton's approximation method was used to find values of the coefficients A, B, C, D, and E, in the conic equation

$$Ax^2 + Bxy + y^2 + Cx + Dy + E = 0,$$

or the discharge ratio - submergence ratio formula

$$Y = \frac{-(Bx + D) + \sqrt{(Bx + D)^2 - 4(Ax^2 + Cx + E)}}{2}$$

for $0 \leq x \leq 0.98$.

Let the function G(A,B,C,D,E) be defined as

$$G(A,B,C,D,E) = \sum_{i=1}^{n} (r_i)^2 = \sum_{i=1}^{n} (Y_i - Y_i')^2$$

$G(A,B,C,D,E) =$

$$\sum_{i=1}^{n} \left\{ Y_i - \left[\frac{-(Bx_i + D) + \sqrt{(Bx_i + D)^2 - 4(Ax_i^2 + Cx_i + E)}}{2} \right] \right\}^2$$

For convenience of notation let

$$(ST) = \left\{ Y_i - \left[\frac{-(Bx_i + D) + \sqrt{(Bx_i + D)^2 - 4(Ax_i^2 + Cx_i + E)}}{2} \right] \right\}$$

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$$(RAD) = [(Bx_i + D)^2 - 4(Ax_i^2 + Cx_i + E)] ,$$

and drop $i = 1$ and n from the summation sign (Σ).

In applying the least squares method to obtain the minimum value of the function $G(A,B,C,D,E)$, partial derivatives are taken of $G(A,B,C,D,E)$. The derivatives are then set equal to zero to form the system of five equations, which are solved simultaneously to find the values of $A,B,C,D,$ and E. The five equations are

(1) $\dfrac{\partial G}{\partial A} = \Sigma\ 2(ST)(RAD)^{-1/2}\ (x_i^2) = 0,$

(2) $\dfrac{\partial G}{\partial B} = \Sigma (ST)\ [1 - (Bx_i + D)(RAD)^{-1/2}](x_i) = 0,$

(3) $\dfrac{\partial G}{\partial C} = \Sigma\ 2(ST)(RAD)^{-1/2}\ (x_i) = 0,$

(4) $\dfrac{\partial G}{\partial D} = \Sigma (ST)\ [1 - (Bx_i + D)(RAD)^{-1/2}] = 0,$

(5) $\dfrac{\partial G}{\partial E} = \Sigma\ 2(ST)(RAD)^{-1/2} = 0.$

The system of five simultaneous equations are not linear for the coefficients A, B, C, D, and E. Therefore, Newton's method of approximations was used to help solve for the values of A, B, C, D, and E, that satisfied the system of the five equations.

Figure b, Appendix C gives a description of Newton's approximation method. The purpose is to find the root value x_r (with desired accuracy) for the equation $f(x) = 0$. An approximate root value (x_1) is substituted in the equation

$$x_2 = x_1 + h_1 \text{ and } h_1 = \frac{-f(x_1)}{f'(x_1)} ,$$

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where

$f(x_1)$ = the value of the function $f(x) = 0$ when $x = x_1$,

$f'(x_1)$ = the value for the derivative of the function $f(x) = 0$ when $x = x_1$,

h_1 = a corrective value which is added to x_1,

x_2 = a second approximation to root x_r which is more accurate than x_1.

Then x_2 is substituted in place of x_1 in the above equation and the third approximation x_3 is obtained. Successive approximations are made until a root value x_r with the desired accuracy is obtained.

The following Equations (6) through (20) are established for the purpose of using Newton's approximation method in solving for the coefficients A, B, C, D, and E in the five simultaneous equations. Applying Newton's method for the coefficient A to obtain the corrective value (h_{1a}),

$$f(x) \text{ is } \frac{\partial G}{\partial A}, \quad f'(x) \text{ is } \frac{\partial^2 G}{\partial A^2}, \text{ and}$$

$$(6) \quad h_{1a} = -\frac{\partial G}{\partial A} \div \frac{\partial^2 G}{\partial A^2}, \quad \text{evaluated for } A = A_1,$$

For the coefficients B, C, D, and E, the respective corrective values are

$$(7) \quad h_{1b} = -\frac{\partial G}{\partial B} \div \frac{\partial^2 G}{\partial B^2}, \quad \text{evaluated for } B = B_1,$$

$$(8) \quad h_{1c} = -\frac{\partial G}{\partial C} \div \frac{\partial^2 G}{\partial C^2}, \quad \text{evaluated for } C = C_1,$$

$$(9) \quad h_{1d} = -\frac{\partial G}{\partial D} \div \frac{\partial^2 G}{\partial D^2}, \quad \text{evaluated for } D = D_1,$$

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(10) $\quad h_{1e} = -\dfrac{\partial G}{\partial E} \div \dfrac{\partial^2 G}{\partial E^2}$, evaluated for $E = E_1$.

The second partial derivatives are taken of the function $G(A,B,C,D,E)$ and are used for obtaining the corrective values (h) for each coefficient

$$(11) \quad \frac{\partial^2 G}{\partial A^2} = \sum (2x_i^4) \left[(2ST)(RAD)^{-3/2} + (RAD)^{-1} \right]$$

$$(12) \quad \frac{\partial^2 G}{\partial B^2} = \sum \left\{ (ST)(x_i^2) \left[(Bx_i + D)^2 (RAD)^{-3/2} - (RAD)^{-1/2} \right] \right.$$
$$\left. + \left(\frac{x_i^2}{2} \right) \left[1 - (Bx_i + D)(RAD)^{-1/2} \right]^2 \right\}$$

$$(13) \quad \frac{\partial^2 G}{\partial C^2} = \sum (2x_i)^2 \left[(2ST)(RAD)^{-3/2} + (RAD)^{-1} \right]$$

$$(14) \quad \frac{\partial^2 G}{\partial D^2} = \sum \left\{ (ST) \left[(Bx_i + D)^2 (RAD)^{-3/2} - (RAD)^{-1/2} \right] \right.$$
$$\left. + \left(\frac{1}{2} \right) \left[1 - (Bx_i + D)(RAD)^{-1/2} \right]^2 \right\}$$

$$(15) \quad \frac{\partial^2 G}{\partial E^2} = \sum (2) \left[(ST)(RAD)^{-3/2} + (RAD)^{-1} \right]$$

The second approximation of the coefficients A_1, B_1, C_1, D_1, and E_1 are

(16) $\quad A_2 = A_1 + h_{1a}$,

(17) $\quad B_2 = B_1 + h_{1b}$,

$$(18) \quad C_2 = C_1 + h_{1c},$$

$$(19) \quad D_2 = D_1 + h_{1d},$$

$$(20) \quad E_2 = E_1 + h_{1e}.$$

A computer program was written and an electronic digital
computer used to solve for the values A, B, C, D, and E.
Equations (1) through (20) and the approximate values of
the coefficients were used. The procedure of the computer
program is as follows. Using an approximate value for the
coefficients in Equation (16) a second approximation of A
(which was more accurate than the first) was computed.
Then the second approximation of A replaced the first in
the computer program. Next Equation (17) was used and a
second approximation of B computed, which replaced the
first approximation of B in the computer program and so
on through coefficient E. Each coefficient A through E
had a corrective value (h_1). The next five approximations

made to the coefficients were based on the corrective val-
ues. Approximations were made first to the coefficients
with the largest corrective value. Starting at the begin-
ning with Equation (16) the described computation proced-
ure was repeated many times until the corrective values
were very small. When the corrective value for each co-
efficient was less than 0.0003 computations were stopped
on the computer. Values of the coefficients obtained are
given in a table in the main part of the report under the
heading, "Submerged Flow Tests." The graphs of the dis-
charge ratio - submergence ratio formulas are shown in
Figures 12, 13 and 14.

A P P E N D I X C
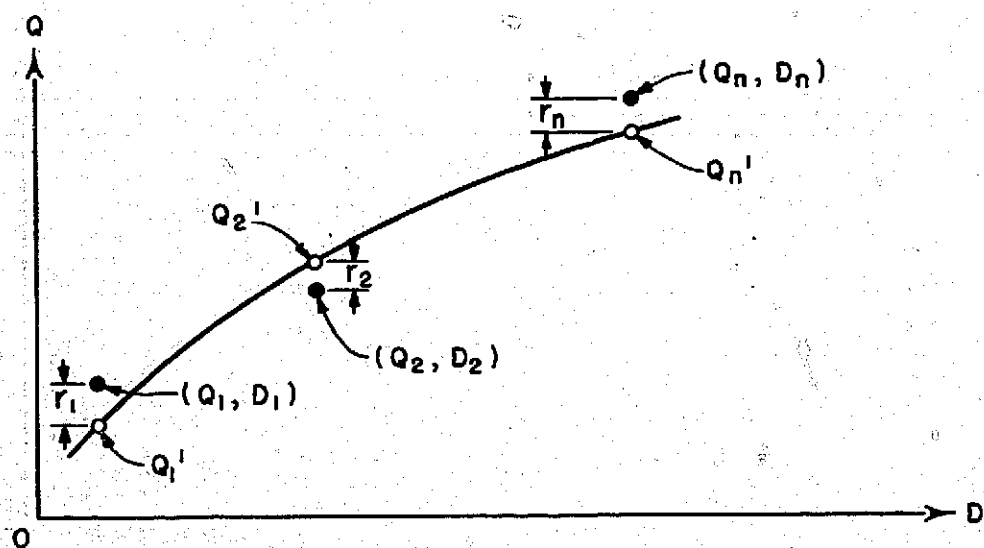
FIGURE A
Residual of Data Points
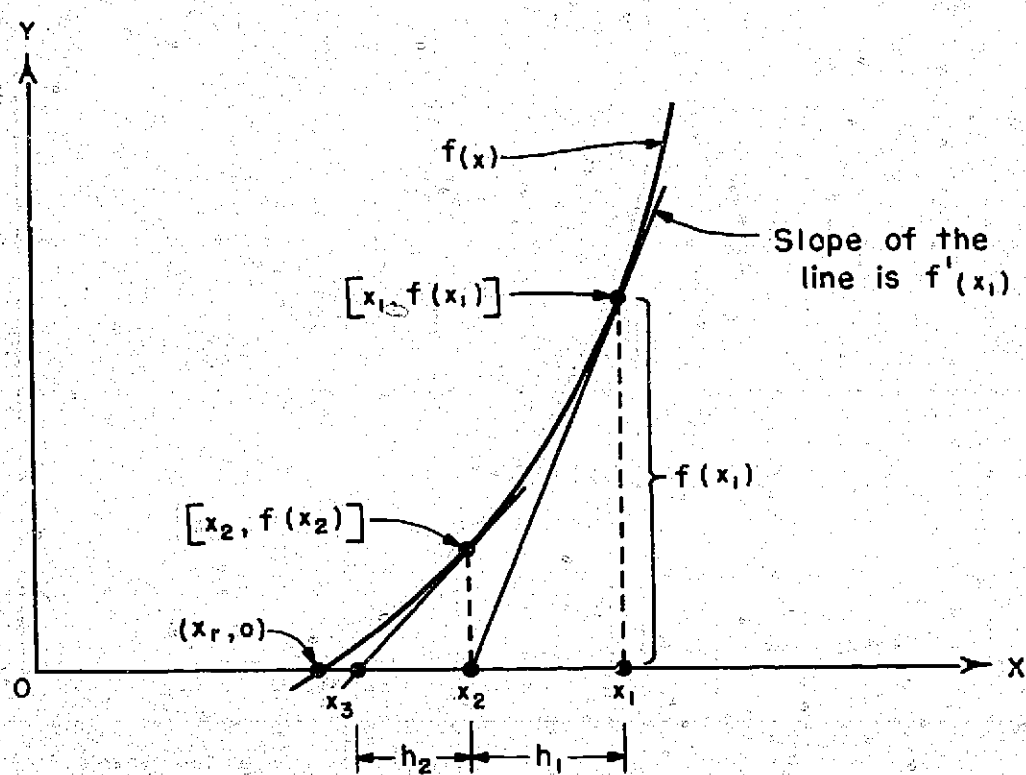
FIGURE B
Newton's Method of Approximation

APPENDIX D.

Discharge in cfs for weir at Station 1335+67

Upstream water depth (Du) 1.40 - 2.22 Feet

Downstream water depth (Dd) 0.0 - 2.4 Feet

0.292

1.417

| Du | Dd - Downstream Water Depth |
	0.0	.20	.40	.60	.80	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40
1.40	9.5	9.4	9.2	8.8	8.2	7.2	5.6	0.	0.	0.	0.	0.	0.
1.42	9.7	9.6	9.4	9.0	8.4	7.4	5.9	0.	0.	0.	C	0.	0.
1.44	9.9	9.8	9.6	9.2	8.6	7.7	6.2	0.	0.	0.	0.	0.	0.
1.46	10.1	10.0	9.8	9.4	8.8	7.9	6.5	0.	0.	0.	0.	0.	0.
1.48	10.3	10.2	10.0	9.6	9.0	8.2	6.7	0.	0.	0.	0.	0.	0.
1.50	10.5	10.4	10.2	9.8	9.3	8.4	7.0	0.	0.	0.	0.	0.	0.
1.52	10.7	10.6	10.4	10.1	9.5	8.6	7.3	0.	0.	0.	0.	0.	0.
1.54	10.9	10.8	10.6	10.3	9.7	8.9	7.6	0.	0.	0.	0.	0.	0.
1.56	11.1	11.1	10.9	10.5	10.0	9.1	7.9	5.7	0.	0.	0.	0.	0.
1.58	11.4	11.3	11.1	10.7	10.2	9.4	8.1	6.1	0.	0.	0.	0.	0.
1.60	11.6	11.5	11.3	11.0	10.4	9.6	8.4	6.5	0.	0.	0.	0.	0.
1.62	11.8	11.7	11.5	11.2	10.7	9.9	8.7	6.8	0.	0.	0.	0.	0.
1.64	12.0	12.0	11.8	11.4	10.9	10.1	9.0	7.2	0.	0.	0.	0.	0.
1.66	12.3	12.2	12.0	11.7	11.2	10.4	9.2	7.5	0.	0.	0.	0.	0.
1.68	12.5	12.4	12.2	11.9	11.4	10.6	9.5	7.8	0.	0.	0.	0.	0.
1.70	12.8	12.7	12.5	12.2	11.6	10.9	9.8	8.2	0.	0.	0.	0.	0.
1.72	13.0	12.9	12.7	12.4	11.9	11.2	10.1	8.5	0.	0.	0.	0.	0.
1.74	13.2	13.2	13.0	12.7	12.2	11.4	10.4	8.8	0.	0.	0.	0.	0.
1.76	13.5	13.4	13.2	12.9	12.4	11.7	10.6	9.1	0.	0.	0.	0.	0.
1.78	13.7	13.7	13.5	13.2	12.7	12.0	10.9	9.4	7.1	0.	0.	0.	0.
1.80	14.0	13.9	13.7	13.4	12.9	12.2	11.2	9.7	7.5	0.	0.	0.	0.
1.82	14.3	14.2	14.0	13.7	13.2	12.5	11.5	10.1	7.9	0.	0.	0.	0.
1.84	14.5	14.4	14.3	13.9	13.5	12.8	11.8	10.4	8.2	0.	0.	0.	0.
1.86	14.8	14.7	14.5	14.2	13.7	13.0	12.1	10.7	8.6	0.	0.	0.	0.
1.88	15.0	15.0	14.8	14.5	14.0	13.3	12.4	11.0	9.0	0.	0.	0.	0.
1.90	15.3	15.2	15.0	14.7	14.3	13.6	12.7	11.3	9.4	0.	0.	0.	0.
1.92	15.6	15.5	15.3	15.0	14.5	13.9	12.9	11.6	9.7	0.	0.	0.	0.
1.94	15.9	15.8	15.6	15.3	14.8	14.2	13.2	12.0	10.1	0.	0.	0.	0.
1.96	16.1	16.0	15.9	15.6	15.1	14.4	13.5	12.3	10.5	0.	0.	0.	0.
1.98	16.4	16.3	16.2	15.8	15.4	14.7	13.8	12.6	10.8	0.	0.	0.	0.
2.00	16.7	16.6	16.4	16.1	15.7	15.0	14.1	12.9	11.2	0.	0.	0.	0.
2.02	17.0	16.9	16.7	16.4	16.0	15.3	14.4	13.2	11.5	9.0	0.	0.	0.
2.04	17.3	17.2	17.0	16.7	16.3	15.6	14.7	13.6	11.9	9.4	0.	0.	0.
2.06	17.6	17.5	17.3	17.0	16.6	15.9	15.1	13.9	12.2	9.8	0.	0.	0.
2.08	17.8	17.8	17.6	17.3	16.8	16.2	15.4	14.2	12.6	10.3	0.	0.	0.
2.10	18.1	18.1	17.9	17.6	17.1	16.5	15.7	14.5	13.0	10.7	0.	0.	0.
2.12	18.4	18.4	18.2	17.9	17.5	16.8	16.0	14.9	13.3	11.1	0.	0.	0.
2.14	18.7	18.7	18.5	18.2	17.8	17.1	16.3	15.2	13.7	11.5	0.	0.	0.
2.16	19.0	19.0	18.8	18.5	18.1	17.5	16.6	15.5	14.0	11.9	0.	0.	0.
2.18	19.4	19.3	19.1	18.8	18.4	17.8	17.0	15.9	14.4	12.3	0.	0.	0.
2.20	19.7	19.6	19.4	19.1	18.7	18.1	17.3	16.2	14.7	12.7	0.	0.	0.
2.22	20.0	19.9	19.7	19.4	19.0	18.4	17.6	16.5	15.1	13.1	0.	0.	C.

Discharge in cfs for weir at Station 1335+67

Upstream water depth (Du) 2.24 - 3.06 Feet

Downstream water depth (Dd) 0.0 - 2.4 Feet

Du	Dd - Downstream Water Depth												
	0.0	.20	.40	.60	.80	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40
2.24	20.3	20.2	20.0	19.8	19.3	18.7	17.9	16.9	15.4	13.5	10.7	0.	0.
2.26	20.6	20.5	20.4	20.1	19.6	19.1	18.3	17.2	15.8	13.9	11.1	0.	0.
2.28	20.9	20.8	20.7	20.4	20.0	19.4	18.6	17.6	16.2	14.3	11.6	0.	0.
2.30	21.3	21.2	21.0	20.7	20.3	19.7	18.9	17.9	16.5	14.7	12.1	0.	0.
2.32	21.6	21.5	21.3	21.0	20.6	20.0	19.3	18.2	16.9	15.1	12.5	0.	0.
2.34	21.9	21.8	21.7	21.4	21.0	20.4	19.6	18.6	17.3	15.5	13.0	0.	0.
2.36	22.2	22.2	22.0	21.7	21.3	20.7	20.0	18.9	17.6	15.9	13.4	0.	0.
2.38	22.6	22.5	22.3	22.0	21.6	21.1	20.3	19.3	18.0	16.3	13.9	0.	0.
2.40	22.9	22.8	22.7	22.4	22.0	21.4	20.6	19.7	18.4	16.7	14.3	0.	0.
2.42	23.3	23.2	23.0	22.7	22.3	21.8	21.0	20.0	18.7	17.1	14.8	0.	0.
2.44	23.6	23.5	23.4	23.1	22.7	22.1	21.4	20.4	19.1	17.5	15.2	0.	0.
2.46	24.0	23.9	23.7	23.4	23.0	22.5	21.7	20.7	19.5	17.8	15.7	12.5	0.
2.48	24.3	24.2	24.1	23.8	23.4	22.8	22.1	21.1	19.9	18.2	16.1	13.0	0.
2.50	24.7	24.6	24.4	24.1	23.7	23.2	22.4	21.5	20.2	18.6	16.5	13.6	0.
2.52	25.0	24.9	24.8	24.5	24.1	23.5	22.8	21.8	20.6	19.0	17.0	14.1	0.
2.54	25.4	25.3	25.1	24.8	24.4	23.9	23.2	22.2	21.0	19.4	17.4	14.6	0.
2.56	25.7	25.6	25.5	25.2	24.8	24.2	23.5	22.6	21.4	19.8	17.8	15.1	0.
2.58	26.1	26.0	25.8	25.6	25.2	24.6	23.9	23.0	21.8	20.2	18.3	15.6	0.
2.60	26.5	26.4	26.2	25.9	25.5	25.0	24.3	23.3	22.2	20.7	18.7	16.0	0.
2.62	26.8	26.7	26.6	26.3	25.9	25.4	24.6	23.7	22.6	21.1	19.1	16.5	0.
2.64	27.2	27.1	27.0	26.7	26.3	25.7	25.0	24.1	22.9	21.5	19.6	17.0	0.
2.66	27.6	27.5	27.3	27.1	26.7	26.1	25.4	24.5	23.3	21.9	20.0	17.5	0.
2.68	28.0	27.9	27.7	27.4	27.0	26.5	25.8	24.9	23.7	22.3	20.4	18.0	14.5
2.70	28.3	28.2	28.1	27.8	27.4	26.9	26.2	25.3	24.1	22.7	20.9	18.5	15.1
2.72	28.7	28.6	28.5	28.2	27.8	27.3	26.6	25.7	24.5	23.1	21.3	18.9	15.7
2.74	29.1	29.0	28.9	28.6	28.2	27.7	27.0	26.1	25.0	23.5	21.7	19.4	16.2
2.76	29.5	29.4	29.2	29.0	28.6	28.0	27.4	26.5	25.4	24.0	22.2	19.9	16.8
2.78	29.9	29.8	29.6	29.4	29.0	28.4	27.8	26.9	25.8	24.4	22.6	20.3	17.3
2.80	30.3	30.2	30.0	29.8	29.4	28.8	28.2	27.3	26.2	24.8	23.1	20.8	17.8
2.82	30.7	30.6	30.4	30.2	29.8	29.2	28.6	27.7	26.6	25.2	23.5	21.3	18.4
2.84	31.1	31.0	30.8	30.6	30.2	29.6	29.0	28.1	27.0	25.7	23.9	21.8	18.9
2.86	31.5	31.4	31.2	31.0	30.6	30.1	29.4	28.5	27.4	26.1	24.4	22.2	19.4
2.88	31.9	31.8	31.6	31.4	31.0	30.5	29.8	28.9	27.8	26.5	24.8	22.7	19.9
2.90	32.3	32.2	32.0	31.8	31.4	30.9	30.2	29.3	28.3	26.9	25.3	23.2	20.5
2.92	32.7	32.6	32.5	32.2	31.8	31.3	30.6	29.8	28.7	27.4	25.7	23.7	21.0
2.94	33.1	33.0	32.9	32.6	32.2	31.7	31.0	30.2	29.1	27.8	26.2	24.1	21.5
2.96	33.6	33.4	33.3	33.0	32.6	32.1	31.5	30.6	29.6	28.3	26.6	24.6	22.0
2.98	34.0	33.9	33.7	33.4	33.1	32.5	31.9	31.0	30.0	28.7	27.1	25.1	22.5
3.00	34.4	34.3	34.1	33.9	33.5	33.0	32.3	31.5	30.4	29.1	27.6	25.6	23.0
3.02	34.8	34.7	34.6	34.3	33.9	33.4	32.7	31.9	30.9	29.6	28.0	26.0	23.6
3.04	35.2	35.1	35.0	34.7	34.3	33.8	33.2	32.3	31.3	30.0	28.5	26.5	24.1
3.06	35.7	35.6	35.4	35.2	34.8	34.3	33.6	32.8	31.8	30.5	28.9	27.0	24.6

Discharge in cfs for weir at Station 1335+67

Upstream water depth (Du) 3.08 - 3.90 Feet

Downstream water depth (Dd) 0.0 - 2.4 Feet

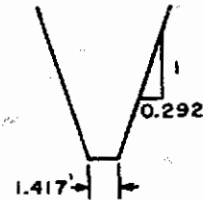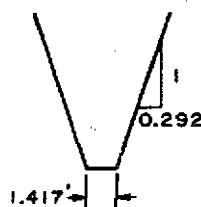| Du	Dd - Downstream Water Depth												
	0.0	.20	.40	.60	.80	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40
3.08	36.1	36.0	35.9	35.6	35.2	34.7	34.0	33.2	32.2	30.9	29.4	27.5	25.1
3.10	36.6	36.4	36.3	36.0	35.6	35.1	34.5	33.7	32.6	31.4	29.9	28.0	25.6
3.12	37.0	36.9	36.7	36.5	36.1	35.6	34.9	34.1	33.1	31.9	30.3	28.5	26.1
3.14	37.4	37.3	37.2	36.9	36.5	36.0	35.4	34.6	33.6	32.3	30.8	29.0	26.6
3.16	37.9	37.8	37.6	37.4	37.0	36.5	35.8	35.0	34.0	32.8	31.3	29.4	27.2
3.18	38.3	38.2	38.1	37.8	37.4	36.9	36.3	35.5	34.5	33.2	31.8	29.9	27.7
3.20	38.8	38.7	38.5	38.3	37.9	37.4	36.7	35.9	34.9	33.7	32.2	30.4	28.2
3.22	39.2	39.1	39.0	38.7	38.3	37.8	37.2	36.4	35.4	34.2	32.7	30.9	28.7
3.24	39.7	39.6	39.4	39.2	38.8	38.3	37.6	36.8	35.9	34.7	33.2	31.4	29.2
3.26	40.2	40.0	39.9	39.6	39.2	38.7	38.1	37.3	36.3	35.1	33.7	31.9	29.7
3.28	40.6	40.5	40.3	40.1	39.7	39.2	38.6	37.8	36.8	35.6	34.2	32.4	30.3
3.30	41.1	41.0	40.8	40.6	40.2	39.7	39.0	38.2	37.3	36.1	34.7	32.9	30.8
3.32	41.6	41.4	41.3	41.0	40.6	40.1	39.5	38.7	37.8	36.6	35.1	33.4	31.3
3.34	42.0	41.9	41.8	41.5	41.1	40.6	40.0	39.2	38.2	37.1	35.6	33.9	31.8
3.36	42.5	42.4	42.2	42.0	41.6	41.1	40.5	39.7	38.7	37.5	36.1	34.4	32.4
3.38	43.0	42.9	42.7	42.4	42.1	41.6	40.9	40.2	39.2	38.0	36.6	34.9	32.9
3.40	43.5	43.3	43.2	42.9	42.5	42.1	41.4	40.6	39.7	38.5	37.1	35.4	33.4
3.42	43.9	43.8	43.7	43.4	43.0	42.5	41.9	41.1	40.2	39.0	37.6	36.0	33.9
3.44	44.4	44.3	44.1	43.9	43.5	43.0	42.4	41.6	40.7	39.5	38.1	36.5	34.5
3.46	44.9	44.8	44.6	44.4	44.0	43.5	42.9	42.1	41.2	40.0	38.6	37.0	35.0
3.48	45.4	45.3	45.1	44.9	44.5	44.0	43.4	42.6	41.7	40.5	39.2	37.5	35.5
3.50	45.9	45.8	45.6	45.4	45.0	44.5	43.9	43.1	42.2	41.0	39.7	38.0	36.1
3.52	46.4	46.3	46.1	45.9	45.5	45.0	44.4	43.6	42.7	41.5	40.2	38.6	36.6
3.54	46.9	46.8	46.6	46.4	46.0	45.5	44.9	44.1	43.2	42.0	40.7	39.1	37.1
3.56	47.4	47.3	47.1	46.9	46.5	46.0	45.4	44.6	43.7	42.6	41.2	39.6	37.7
3.58	47.9	47.8	47.6	47.4	47.0	46.5	45.9	45.1	44.2	43.1	41.7	40.1	38.2
3.60	48.4	48.3	48.1	47.9	47.5	47.0	46.4	45.6	44.7	43.6	42.3	40.7	38.8
3.62	48.9	48.8	48.6	48.4	48.0	47.5	46.9	46.2	45.2	44.1	42.8	41.2	39.3
3.64	49.4	49.3	49.1	48.9	48.5	48.0	47.4	46.7	45.7	44.6	43.3	41.7	39.9
3.66	49.9	49.8	49.7	49.4	49.0	48.6	47.9	47.2	46.3	45.2	43.8	42.3	40.4
3.68	50.5	50.3	50.2	49.9	49.6	49.1	48.5	47.7	46.8	45.7	44.4	42.8	41.0
3.70	51.0	50.9	50.7	50.4	50.1	49.6	49.0	48.2	47.3	46.2	44.9	43.4	41.5
3.72	51.5	51.4	51.2	51.0	50.6	50.1	49.5	48.8	47.9	46.8	45.5	43.9	42.1
3.74	52.0	51.9	51.8	51.5	51.1	50.7	50.0	49.3	48.4	47.3	46.0	44.5	42.6
3.76	52.6	52.4	52.3	52.0	51.7	51.2	50.6	49.8	48.9	47.8	46.5	45.0	43.2
3.78	53.1	53.0	52.8	52.6	52.2	51.7	51.1	50.4	49.5	48.4	47.1	45.6	43.8
3.80	53.6	53.5	53.4	53.1	52.7	52.3	51.7	50.9	50.0	48.9	47.6	46.1	44.3
3.82	54.2	54.1	53.9	53.6	53.3	52.8	52.2	51.4	50.5	49.5	48.2	46.7	44.9
3.84	54.7	54.6	54.4	54.2	53.8	53.3	52.7	52.0	51.1	50.0	48.7	47.2	45.5
3.86	55.3	55.1	55.0	54.7	54.4	53.9	53.3	52.5	51.6	50.6	49.3	47.8	46.1
3.88	55.8	55.7	55.5	55.3	54.9	54.4	53.8	53.1	52.2	51.1	49.9	48.4	46.6
3.90	56.4	56.2	56.1	55.8	55.5	55.0	54.4	53.6	52.7	51.7	50.4	48.9	47.2

APPENDIX D. - Continued

Discharge in cfs for weir at Station 1335+67

Upstream water depth (Du) 3.92 - 4.74 Feet

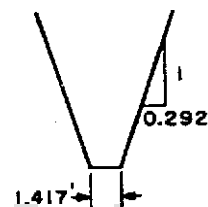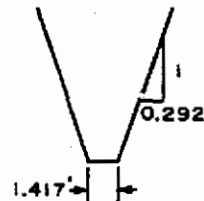Downstream water depth (Dd) 0.0 - 2.4 Feet

Du	Dd ~ Downstream Water Depth

Du	0.0	.20	.40	.60	.80	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40
3.92	56.9	56.8	56.6	56.4	56.0	55.5	54.9	54.2	53.3	52.2	51.0	49.5	47.8
3.94	57.5	57.3	57.2	56.9	56.6	56.1	55.5	54.8	53.9	52.8	51.6	50.1	48.4
3.96	58.0	57.9	57.7	57.5	57.1	56.6	56.1	55.3	54.4	53.4	52.1	50.7	48.9
3.98	58.6	58.5	58.3	58.0	57.7	57.2	56.6	55.9	55.0	53.9	52.7	51.2	49.5
4.00	59.2	59.0	58.9	58.6	58.2	57.8	57.2	56.4	55.6	54.5	53.3	51.8	50.1
4.02	59.7	59.6	59.4	59.2	58.8	58.3	57.7	57.0	56.1	55.1	53.9	52.4	50.7
4.04	60.3	60.2	60.0	59.7	59.4	58.9	58.3	57.6	56.7	55.7	54.4	53.0	51.3
4.06	60.9	60.7	60.6	60.3	60.0	59.5	58.9	58.2	57.3	56.2	55.0	53.6	51.9
4.08	61.4	61.3	61.1	60.9	60.5	60.1	59.5	58.7	57.9	56.8	55.6	54.2	52.5
4.10	62.0	61.9	61.7	61.5	61.1	60.6	60.0	59.3	58.4	57.4	56.2	54.8	53.1
4.12	62.6	62.5	62.3	62.1	61.7	61.2	60.6	59.9	59.0	58.0	56.8	55.4	53.7
4.14	63.2	63.1	62.9	62.6	62.3	61.8	61.2	60.5	59.6	58.6	57.4	56.0	54.3
4.16	63.8	63.6	63.5	63.2	62.9	62.4	61.8	61.1	60.2	59.2	58.0	56.6	54.9
4.18	64.4	64.2	64.1	63.8	63.5	63.0	62.4	61.7	60.8	59.8	58.6	57.2	55.5
4.20	65.0	64.8	64.7	64.4	64.0	63.6	63.0	62.3	61.4	60.4	59.2	57.8	56.1
4.22	65.6	65.4	65.3	65.0	64.6	64.2	63.6	62.9	62.0	61.0	59.8	58.4	56.8
4.24	66.2	66.0	65.8	65.6	65.2	64.8	64.2	63.5	62.6	61.6	60.4	59.0	57.4
4.26	66.8	66.6	66.4	66.2	65.8	65.4	64.8	64.1	63.2	62.2	61.0	59.6	58.0
4.28	67.4	67.2	67.1	66.8	66.4	66.0	65.4	64.7	63.8	62.8	61.6	60.2	58.6
4.30	68.0	67.8	67.7	67.4	67.0	66.6	66.0	65.3	64.4	63.4	62.2	60.8	59.2
4.32	68.6	68.4	68.3	68.0	67.7	67.2	66.6	65.9	65.0	64.0	62.8	61.5	59.9
4.34	69.2	69.0	68.9	68.6	68.3	67.8	67.2	66.5	65.7	64.6	63.5	62.1	60.5
4.36	69.8	69.7	69.5	69.2	68.9	68.4	67.8	67.1	66.3	65.3	64.1	62.7	61.1
4.38	70.4	70.3	70.1	69.9	69.5	69.0	68.5	67.7	66.9	65.9	64.7	63.3	61.8
4.40	71.0	70.9	70.7	70.5	70.1	69.7	69.1	68.4	67.5	66.5	65.3	64.0	62.4
4.42	71.7	71.5	71.4	71.1	70.7	70.3	69.7	69.0	68.1	67.1	66.0	64.6	63.0
4.44	72.3	72.1	72.0	71.7	71.4	70.9	70.3	69.6	68.8	67.8	66.6	65.3	63.7
4.46	72.9	72.8	72.6	72.4	72.0	71.5	71.0	70.2	69.4	68.4	67.2	65.9	64.3
4.48	73.6	73.4	73.2	73.0	72.6	72.2	71.6	70.9	70.0	69.0	67.9	66.5	65.0
4.50	74.2	74.0	73.9	73.6	73.3	72.8	72.2	71.5	70.7	69.7	68.5	67.2	65.6
4.52	74.8	74.7	74.5	74.3	73.9	73.4	72.9	72.2	71.3	70.3	69.2	67.8	66.3
4.54	75.5	75.3	75.2	74.9	74.5	74.1	73.5	72.8	72.0	71.0	69.8	68.5	66.9
4.56	76.1	76.0	75.8	75.5	75.2	74.7	74.1	73.4	72.6	71.6	70.5	69.1	67.6
4.58	76.8	76.6	76.4	76.2	75.8	75.4	74.8	74.1	73.3	72.3	71.1	69.8	68.3
4.60	77.4	77.2	77.1	76.8	76.5	76.0	75.4	74.7	73.9	72.9	71.8	70.4	68.9
4.62	78.1	77.9	77.7	77.5	77.1	76.7	76.1	75.4	74.6	73.6	72.4	71.1	69.6
4.64	78.7	78.6	78.4	78.1	77.8	77.3	76.7	76.0	75.2	74.2	73.1	71.8	70.3
4.66	79.4	79.2	79.0	78.8	78.4	78.0	77.4	76.7	75.9	74.9	73.8	72.4	70.9
4.68	80.0	79.9	79.7	79.5	79.1	78.6	78.1	77.4	76.5	75.6	74.4	73.1	71.6
4.70	80.7	80.5	80.4	80.1	79.8	79.3	78.7	78.0	77.2	76.2	75.1	73.8	72.3
4.72	81.4	81.2	81.0	80.8	80.4	80.0	79.4	78.7	77.9	76.9	75.8	74.5	73.0
4.74	82.0	81.9	81.7	81.4	81.1	80.6	80.1	79.4	78.5	77.6	76.4	75.1	73.6

0.292

1.417'

Discharge in cfs for weir at Station 1335+67

Upstream water depth (Du) 4.76 - 5.44 Feet

Downstream water depth (Dd) 0.0 - 2.4 Feet

Du	Dd - Downstream Water Depth												
	0.0	.20	.40	.60	.80	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40
4.76	82.7	82.5	82.4	82.1	81.8	81.3	80.7	80.0	79.2	78.2	77.1	75.8	74.3
4.78	83.4	83.2	83.0	82.8	82.4	82.0	81.4	80.7	79.9	78.9	77.8	76.5	75.0
4.80	84.0	83.9	83.7	83.5	83.1	82.7	82.1	81.4	80.6	79.6	78.5	77.2	75.7
4.82	84.7	84.6	84.4	84.1	83.8	83.3	82.8	82.1	81.2	80.3	79.2	77.9	76.4
4.84	85.4	85.2	85.1	84.8	84.5	84.0	83.4	82.8	81.9	81.0	79.9	78.6	77.1
4.86	86.1	85.9	85.8	85.5	85.2	84.7	84.1	83.4	82.6	81.7	80.5	79.3	77.8
4.88	86.8	86.6	86.5	86.2	85.9	85.4	84.8	84.1	83.3	82.4	81.2	80.0	78.5
4.90	87.5	87.3	87.1	86.9	86.5	86.1	85.5	84.8	84.0	83.0	81.9	80.6	79.2
4.92	88.2	88.0	87.8	87.6	87.2	86.8	86.2	85.5	84.7	83.7	82.6	81.4	79.9
4.94	88.9	88.7	88.5	88.3	87.9	87.5	86.9	86.2	85.4	84.4	83.3	82.1	80.6
4.96	89.6	89.4	89.2	89.0	88.6	88.2	87.6	86.9	86.1	85.1	84.0	82.8	81.3
4.98	90.3	90.1	89.9	89.7	89.3	88.9	88.3	87.6	86.8	85.9	84.7	83.5	82.0
5.00	91.0	90.8	90.6	90.4	90.0	89.6	89.0	88.3	87.5	86.6	85.5	84.2	82.7
5.02	91.7	91.5	91.4	91.1	90.7	90.3	89.7	89.0	88.2	87.3	86.2	84.9	83.5
5.04	92.4	92.2	92.1	91.8	91.5	91.0	90.4	89.7	88.9	88.0	86.9	85.6	84.2
5.06	93.1	92.9	92.8	92.5	92.2	91.7	91.1	90.5	89.6	88.7	87.6	86.3	84.9
5.08	93.8	93.7	93.5	93.2	92.9	92.4	91.9	91.2	90.4	89.4	88.3	87.1	85.6
5.10	94.5	94.4	94.2	94.0	93.6	93.1	92.6	91.9	91.1	90.1	89.0	87.8	86.4
5.12	95.3	95.1	94.9	94.7	94.3	93.9	93.3	92.6	91.8	90.9	89.8	88.5	87.1
5.14	96.0	95.8	95.7	95.4	95.0	94.6	94.0	93.3	92.5	91.6	90.5	89.2	87.8
5.16	96.7	96.5	96.4	96.1	95.8	95.3	94.8	94.1	93.3	92.3	91.2	90.0	88.6
5.18	97.5	97.3	97.1	96.9	96.5	96.1	95.5	94.8	94.0	93.1	92.0	90.7	89.3
5.20	98.2	98.0	97.8	97.6	97.2	96.8	96.2	95.5	94.7	93.8	92.7	91.5	90.0
5.22	98.9	98.7	98.6	98.3	98.0	97.5	97.0	96.3	95.5	94.5	93.4	92.2	90.8
5.24	99.7	99.5	99.3	99.1	98.7	98.3	97.7	97.0	96.2	95.3	94.2	92.9	91.5
5.26	0.	0.	0.	99.8	99.5	99.0	98.4	97.8	97.0	96.0	94.9	93.7	92.3
5.28	0.	0.	0.	0.	0.	99.7	99.2	98.5	97.7	96.8	95.7	94.4	93.0
5.30	0.	0.	0.	0.	0.	0.	0.	99.3	98.5	97.5	96.4	95.2	93.8
5.32	0.	0.	0.	0.	0.	0.	0.	0.	99.2	98.3	97.2	96.0	94.6
5.34	0.	0.	0.	0.	0.	0.	0.	0.	0.	99.0	97.9	96.7	95.3
5.36	0.	0.	0.	0.	0.	0.	0.	0.	0.	99.8	98.7	97.5	96.1
5.38	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	99.5	98.2	96.8
5.40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	99.0	97.6
5.42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	99.8	98.4
5.44	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	99.2
5.46	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5.48	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5.50	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5.52	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5.54	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5.56	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5.58	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

Discharge in cfs for weir at Station 1430+08

Upstream water depth (Du) 0.50 - 1.48 Feet

Downstream water depth (Dd) 0.0 - 1.2 Feet

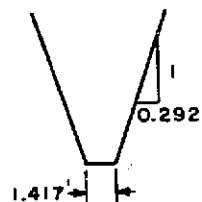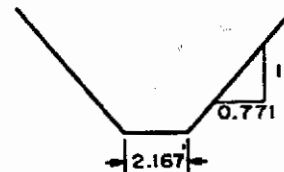| Du	Dd – Downstream Water Depth												
	0.	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00	1.10	1.20
.50	3.3	3.2	3.1	2.8	2.2	0.	0.	0.	0.	0.	0.	0.	0.
.52	3.4	3.3	3.2	2.9	2.4	0.	0.	0.	0.	0.	0.	0.	0.
.54	3.6	3.5	3.4	3.1	2.7	0.	0.	0.	0.	0.	0.	0.	0.
.56	3.7	3.7	3.6	3.3	2.9	2.0	0.	0.	0.	0.	0.	0.	0.
.58	3.9	3.9	3.7	3.5	3.1	2.3	0.	0.	0.	0.	0.	0.	0.
.60	4.1	4.0	3.9	3.7	3.3	2.6	0.	0.	0.	0.	0.	0.	0.
.62	4.3	4.2	4.1	3.9	3.5	2.9	0.	0.	0.	0.	0.	0.	0.
.64	4.5	4.4	4.3	4.1	3.8	3.1	0.	0.	0.	0.	0.	0.	0.
.66	4.7	4.6	4.5	4.3	4.0	3.4	0.	0.	0.	0.	0.	0.	0.
.68	4.9	4.8	4.7	4.5	4.2	3.7	2.7	0.	0.	0.	0.	0.	0.
.70	5.1	5.0	4.9	4.8	4.4	3.9	3.1	0.	0.	0.	0.	0.	0.
.72	5.3	5.3	5.2	5.0	4.7	4.2	3.4	0.	0.	0.	0.	0.	0.
.74	5.6	5.5	5.4	5.2	4.9	4.4	3.7	0.	0.	0.	0.	0.	0.
.76	5.8	5.7	5.6	5.5	5.2	4.7	4.0	0.	0.	0.	0.	0.	0.
.78	6.0	6.0	5.9	5.7	5.4	5.0	4.3	3.2	0.	0.	0.	0.	0.
.80	6.3	6.2	6.1	5.9	5.7	5.3	4.6	3.6	0.	0.	0.	0.	0.
.82	6.5	6.5	6.4	6.2	5.9	5.5	4.9	3.9	0.	0.	0.	0.	0.
.84	6.8	6.7	6.6	6.5	6.2	5.8	5.2	4.3	0.	0.	0.	0.	0.
.86	7.1	7.0	6.9	6.7	6.5	6.1	5.5	4.7	0.	0.	0.	0.	0.
.88	7.3	7.3	7.2	7.0	6.8	6.4	5.8	5.0	0.	0.	0.	0.	0.
.90	7.6	7.5	7.4	7.3	7.0	6.7	6.1	5.4	4.1	0.	0.	0.	0.
.92	7.9	7.8	7.7	7.6	7.3	7.0	6.5	5.7	4.6	0.	0.	0.	0.
.94	8.2	8.1	8.0	7.9	7.6	7.3	6.8	6.1	5.0	0.	0.	0.	0.
.96	8.5	8.4	8.3	8.2	7.9	7.6	7.1	6.4	5.4	0.	0.	0.	0.
.98	8.8	8.7	8.6	8.5	8.2	7.9	7.4	6.7	5.8	0.	0.	0.	0.
1.00	9.1	9.0	8.9	8.8	8.5	8.2	7.7	7.1	6.2	0.	0.	0.	0.
1.02	9.4	9.3	9.2	9.1	8.9	8.5	8.1	7.5	6.6	5.2	0.	0.	0.
1.04	9.7	9.6	9.6	9.4	9.2	8.9	8.4	7.8	7.0	5.7	0.	0.	0.
1.06	10.1	10.0	9.9	9.7	9.5	9.2	8.8	8.2	7.3	6.1	0.	0.	0.
1.08	10.4	10.3	10.2	10.1	9.9	9.5	9.1	8.5	7.7	6.6	0.	0.	0.
1.10	10.8	10.6	10.6	10.4	10.2	9.9	9.5	8.9	8.1	7.0	0.	0.	0.
1.12	11.1	11.0	10.9	10.8	10.6	10.2	9.8	9.3	8.5	7.5	5.9	0.	0.
1.14	11.5	11.3	11.3	11.1	10.9	10.6	10.2	9.7	8.9	7.9	6.4	0.	0.
1.16	11.8	11.7	11.6	11.5	11.3	11.0	10.6	10.0	9.3	8.3	7.0	0.	0.
1.18	12.2	12.1	12.0	11.9	11.6	11.3	10.9	10.4	9.7	8.8	7.5	0.	0.
1.20	12.6	12.4	12.4	12.2	12.0	11.7	11.3	10.8	10.1	9.2	8.0	0.	0.
1.22	12.9	12.8	12.7	12.6	12.4	12.1	11.7	11.2	10.5	9.7	8.4	0.	0.
1.24	13.3	13.2	13.1	13.0	12.8	12.5	12.1	11.6	11.0	10.1	8.9	7.3	0.
1.26	13.7	13.6	13.5	13.4	13.2	12.9	12.5	12.0	11.4	10.5	9.4	7.8	0.
1.28	14.1	14.0	13.9	13.8	13.6	13.3	12.9	12.4	11.8	11.0	9.9	8.4	0.
1.30	14.5	14.4	14.3	14.2	14.0	13.7	13.3	12.8	12.2	11.4	10.4	8.9	0.
1.32	14.9	14.8	14.7	14.6	14.4	14.1	13.7	13.3	12.7	11.9	10.8	9.5	0.
1.34	15.4	15.2	15.1	15.0	14.8	14.5	14.2	13.7	13.1	12.3	11.3	10.0	8.1
1.36	15.8	15.6	15.6	15.4	15.2	15.0	14.6	14.1	13.5	12.8	11.8	10.5	8.7
1.38	16.2	16.1	16.0	15.9	15.7	15.4	15.0	14.6	14.0	13.2	12.3	11.0	9.3
1.40	16.7	16.5	16.4	16.3	16.1	15.8	15.5	15.0	14.4	13.7	12.8	11.6	9.9
1.42	17.1	16.9	16.9	16.7	16.5	16.3	15.9	15.5	14.9	14.2	13.3	12.1	10.5
1.44	17.6	17.4	17.3	17.2	17.0	16.7	16.4	15.9	15.4	14.7	13.8	12.6	11.1
1.46	18.0	17.8	17.8	17.6	17.5	17.2	16.8	16.4	15.8	15.1	14.3	13.1	11.7
1.48	18.5	18.3	18.2	18.1	17.9	17.7	17.3	16.9	16.3	15.6	14.8	13.7	12.3

Discharge in cfs for weir at Station 1430+08

Upstream water depth (Du) 1.50 – 2.48 Feet

Downstream water depth (Dd) 0.0 – 1.2 Feet

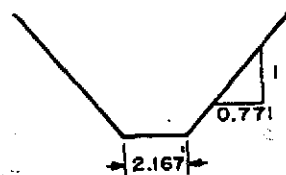| Du	Dd – Downstream Water Depth

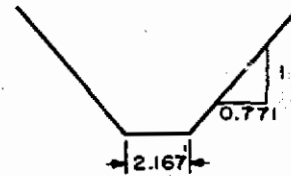| Du	0.	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00	1.10	1.20
1.50	19.0	18.8	18.7	18.6	18.4	18.1	17.8	17.3	16.8	16.1	15.3	14.2	12.8
1.52	19.4	19.2	19.2	19.0	18.9	18.6	18.3	17.8	17.3	16.6	15.8	14.7	13.4
1.54	19.9	19.7	19.7	19.5	19.3	19.1	18.7	18.3	17.8	17.1	16.3	15.3	14.0
1.56	20.4	20.2	20.1	20.0	19.8	19.6	19.2	18.8	18.3	17.6	16.8	15.8	14.5
1.58	20.9	20.7	20.6	20.5	20.3	20.1	19.7	19.3	18.8	18.1	17.3	16.4	15.1
1.60	21.4	21.2	21.1	21.0	20.8	20.6	20.2	19.8	19.3	18.7	17.9	16.9	15.7
1.62	21.9	21.7	21.6	21.5	21.3	21.1	20.7	20.3	19.8	19.2	18.4	17.4	16.3
1.64	22.4	22.2	22.1	22.0	21.8	21.6	21.3	20.8	20.3	19.7	18.9	18.0	16.8
1.66	22.9	22.7	22.7	22.5	22.4	22.1	21.8	21.4	20.9	20.2	19.5	18.6	17.4
1.68	23.5	23.3	23.2	23.1	22.9	22.6	22.3	21.9	21.4	20.8	20.0	19.1	18.0
1.70	24.0	23.8	23.7	23.6	23.4	23.2	22.8	22.4	21.9	21.3	20.6	19.7	18.6
1.72	24.5	24.3	24.3	24.1	23.9	23.7	23.4	23.0	22.5	21.9	21.1	20.3	19.2
1.74	25.1	24.9	24.8	24.7	24.5	24.2	23.9	23.5	23.0	22.4	21.7	20.8	19.8
1.76	25.6	25.4	25.3	25.2	25.0	24.8	24.5	24.1	23.6	23.0	22.3	21.4	20.4
1.78	26.2	26.0	25.9	25.8	25.6	25.4	25.0	24.6	24.2	23.6	22.9	22.0	21.0
1.80	26.8	26.5	26.5	26.3	26.2	25.9	25.6	25.2	24.7	24.1	23.4	22.6	21.6
1.82	27.3	27.1	27.0	26.9	26.7	26.5	26.2	25.8	25.3	24.7	24.0	23.2	22.2
1.84	27.9	27.7	27.6	27.5	27.3	27.1	26.7	26.4	25.9	25.3	24.6	23.8	22.8
1.86	28.5	28.3	28.2	28.1	27.9	27.6	27.3	26.9	26.5	25.9	25.2	24.4	23.4
1.88	29.1	28.8	28.8	28.6	28.5	28.2	27.9	27.5	27.1	26.5	25.8	25.0	24.0
1.90	29.7	29.4	29.4	29.2	29.1	28.8	28.5	28.1	27.7	27.1	26.4	25.6	24.7
1.92	30.3	30.0	30.0	29.8	29.7	29.4	29.1	28.7	28.3	27.7	27.0	26.2	25.3
1.94	30.9	30.6	30.6	30.4	30.3	30.0	29.7	29.3	28.9	28.3	27.7	26.9	25.9
1.96	31.5	31.3	31.2	31.1	30.9	30.6	30.3	30.0	29.5	28.9	28.3	27.5	26.6
1.98	32.2	31.9	31.8	31.7	31.5	31.3	31.0	30.6	30.1	29.6	28.9	28.1	27.2
2.00	32.8	32.5	32.4	32.3	32.1	31.9	31.6	31.2	30.8	30.2	29.6	28.8	27.9
2.02	33.4	33.1	33.1	32.9	32.8	32.5	32.2	31.8	31.4	30.8	30.2	29.4	28.5
2.04	34.1	33.8	33.7	33.6	33.4	33.2	32.9	32.5	32.0	31.5	30.9	30.1	29.2
2.06	34.7	34.4	34.3	34.2	34.0	33.8	33.5	33.1	32.7	32.1	31.5	30.8	29.9
2.08	35.4	35.1	35.0	34.9	34.7	34.5	34.2	33.8	33.3	32.8	32.2	31.4	30.6
2.10	36.0	35.7	35.6	35.5	35.4	35.1	34.8	34.5	34.0	33.5	32.8	32.1	31.2
2.12	36.7	36.4	36.3	36.2	36.0	35.8	35.5	35.1	34.7	34.1	33.5	32.8	31.9
2.14	37.4	37.0	37.0	36.9	36.7	36.5	36.2	35.8	35.3	34.8	34.2	33.5	32.6
2.16	38.1	37.7	37.7	37.5	37.4	37.1	36.8	36.5	36.0	35.5	34.9	34.2	33.3
2.18	38.7	38.4	38.3	38.2	38.0	37.8	37.5	37.2	36.7	36.2	35.6	34.8	34.0
2.20	39.4	39.1	39.0	38.9	38.7	38.5	38.2	37.8	37.4	36.9	36.3	35.6	35.4
2.22	40.1	39.8	39.7	39.6	39.4	39.2	38.9	38.5	38.1	37.6	37.0	36.3	36.2
2.24	40.8	40.5	40.4	40.3	40.1	39.9	39.6	39.2	38.8	38.3	39.0	38.4	36.9
2.26	41.6	41.2	41.1	41.0	40.8	40.6	40.3	40.0	39.5	39.0	39.7	39.1	37.6
2.28	42.3	41.9	41.8	41.7	41.6	41.3	41.0	40.7	41.0	40.5	39.9	39.2	38.3
2.30	43.0	42.6	42.6	42.4	42.3	42.0	41.8	42.5	41.7	41.2	40.6	39.9	39.1
2.32	43.7	43.4	43.3	43.2	43.0	42.8	43.2	42.9	42.4	41.9	41.3	40.6	39.8
2.34	44.5	44.1	44.0	43.9	44.5	44.2	44.0	43.6	43.2	42.7	42.1	41.4	40.6
2.36	45.2	44.8	44.8	44.6	45.2	45.0	44.7	44.3	43.9	43.4	42.8	42.1	41.4
2.38	46.0	45.6	45.5	45.4	46.0	45.7	45.5	45.1	44.7	44.2	43.6	42.9	42.1
2.40	46.7	46.3	46.3	46.1	46.7	46.5	46.2	45.9	45.4	44.9	44.4	43.7	42.9
2.42	47.5	47.1	47.0	46.9	47.5	47.3	47.0	46.6	46.2	45.7	45.1	44.5	43.7
2.44	48.3	47.8	47.8	47.7	48.3	48.0	47.7	47.4	47.0	46.5	45.9	45.2	44.5
2.46	49.0	48.6	48.5	48.4	49.0	48.8	48.5	48.2	47.8	47.3	46.7	46.0	45.3
2.48	49.8	49.4	49.3	49.2	49.0	48.8	48.5	48.2	47.8	47.3	46.7	46.0	45.3

Discharge in cfs for weir at Station 1430+08

Upstream water depth (Du) 2.50 - 3.28 Feet

Downstream water depth (Dd) 0.0 - 1.2 Feet

Du	Dd - Downstream Water Depth												
	0.	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00	1.10	1.20
2.50	50.6	50.2	50.1	50.0	49.8	49.6	49.3	49.0	48.5	48.1	47.5	46.8	46.0
2.52	51.4	51.0	50.9	50.8	50.6	50.4	50.1	49.8	49.3	48.8	48.3	47.6	46.9
2.54	52.2	51.8	51.7	51.6	51.4	51.2	50.9	50.6	50.1	49.6	49.1	48.4	47.7
2.56	53.0	52.6	52.5	52.4	52.2	52.0	51.7	51.4	50.9	50.5	49.9	49.2	48.5
2.58	53.8	53.4	53.3	53.2	53.0	52.8	52.5	52.2	51.8	51.3	50.7	50.0	49.3
2.60	54.7	54.2	54.1	54.0	53.8	53.6	53.3	53.0	52.6	52.1	51.5	50.9	50.1
2.62	55.5	55.0	54.9	54.8	54.7	54.4	54.2	53.8	53.4	52.9	52.3	51.7	51.0
2.64	56.3	55.8	55.8	55.7	55.5	55.3	55.0	54.6	54.2	53.7	53.2	52.5	51.8
2.66	57.2	56.7	56.6	56.5	56.3	56.1	55.8	55.5	55.1	54.6	54.0	53.4	52.6
2.68	58.0	57.5	57.4	57.3	57.2	56.9	56.7	56.3	55.9	55.4	54.9	54.2	53.5
2.70	58.9	58.4	58.3	58.2	58.0	57.8	57.5	57.2	56.8	56.3	55.7	55.1	54.3
2.72	59.7	59.2	59.1	59.0	58.9	58.6	58.4	58.0	57.6	57.1	56.6	55.9	55.2
2.74	60.6	60.1	60.0	59.9	59.7	59.5	59.2	58.9	58.5	58.0	57.4	56.8	56.1
2.76	61.5	60.9	60.9	60.8	60.6	60.4	60.1	59.7	59.3	58.9	58.3	57.7	57.0
2.78	62.3	61.8	61.7	61.6	61.5	61.2	61.0	60.6	60.2	59.7	59.2	58.6	57.8
2.80	63.2	62.7	62.6	62.5	62.3	62.1	61.8	61.5	61.1	60.6	60.1	59.4	58.7
2.82	64.1	63.6	63.5	63.4	63.2	63.0	62.7	62.4	62.0	61.5	61.0	60.3	59.6
2.84	65.0	64.5	64.4	64.3	64.1	63.9	63.6	63.3	62.9	62.4	61.9	61.2	60.5
2.86	65.9	65.4	65.3	65.2	65.0	64.8	64.5	64.2	63.8	63.3	62.8	62.1	61.4
2.88	66.8	66.3	66.2	66.1	65.9	65.7	65.4	65.1	64.7	64.2	63.7	63.0	62.3
2.90	67.7	67.2	67.1	67.0	66.8	66.6	66.3	66.0	65.6	65.1	64.6	64.0	63.3
2.92	68.7	68.1	68.0	67.9	67.7	67.5	67.2	66.9	66.5	66.0	65.5	64.9	64.2
2.94	69.6	69.0	68.9	68.8	68.7	68.4	68.2	67.8	67.4	67.0	66.4	65.8	65.1
2.96	70.5	69.9	69.9	69.8	69.6	69.4	69.1	68.8	68.4	67.9	67.4	66.7	66.0
2.98	71.5	70.9	70.8	70.7	70.5	70.3	70.0	69.7	69.3	68.8	68.3	67.7	67.0
3.00	72.4	71.8	71.7	71.6	71.5	71.2	71.0	70.6	70.2	69.8	69.2	68.6	67.9
3.02	73.4	72.8	72.7	72.6	72.4	72.2	71.9	71.6	71.2	70.7	70.2	69.6	68.9
3.04	74.3	73.7	73.6	73.5	73.4	73.2	72.9	72.5	72.2	71.7	71.2	70.5	69.9
3.06	75.3	74.7	74.6	74.5	74.3	74.1	73.8	73.5	73.1	72.7	72.1	71.5	70.8
3.08	76.3	75.6	75.6	75.5	75.3	75.1	74.8	74.5	74.1	73.6	73.1	72.5	71.8
3.10	77.3	76.6	76.5	76.4	76.3	76.1	75.8	75.5	75.1	74.6	74.1	73.5	72.8
3.12	78.3	77.6	77.5	77.4	77.2	77.0	76.8	76.4	76.0	75.6	75.1	74.4	73.8
3.14	79.2	78.6	78.5	78.4	78.2	78.0	77.7	77.4	77.0	76.6	76.0	75.4	74.8
3.16	80.2	79.6	79.5	79.4	79.2	79.0	78.7	78.4	78.0	77.6	77.0	76.4	75.8
3.18	81.3	80.6	80.5	80.4	80.2	80.0	79.7	79.4	79.0	78.6	78.0	77.4	76.8
3.20	82.3	81.6	81.5	81.4	81.2	81.0	80.7	80.4	80.0	79.6	79.0	78.5	77.8
3.22	83.3	82.6	82.5	82.4	82.2	82.0	81.8	81.4	81.0	80.6	80.1	79.5	78.8
3.24	84.3	83.6	83.5	83.4	83.3	83.0	82.8	82.4	82.1	81.6	81.1	80.5	79.8
3.26	85.3	84.6	84.6	84.4	84.3	84.1	83.8	83.5	83.1	82.6	82.1	81.5	80.8
3.28	86.4	85.7	85.6	85.5	85.3	85.1	84.8	84.5	84.1	83.7	83.1	82.6	81.9

Discharge in cfs for weir at Station 1430+08

Upstream water depth (Du) 1.40 - 2.38 Feet

Downstream water depth (Dd) 1.3 - 2.5 Feet

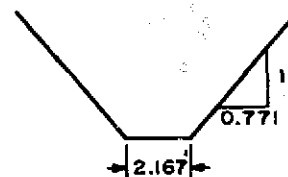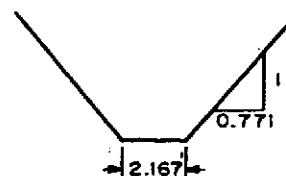| Du	Dd - Downstream Water Depth												
	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50
1.40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.44	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.46	9.7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.48	10.3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.50	11.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.52	11.6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.54	12.3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.56	12.9	10.7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.58	13.5	11.4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.60	14.2	12.1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.62	14.8	12.8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.64	15.4	13.5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.66	16.0	14.2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.68	16.6	14.9	12.5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.70	17.2	15.5	13.3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.72	17.9	16.2	14.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.74	18.5	16.9	14.8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.76	19.1	17.5	15.5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.78	19.7	18.2	16.2	13.6	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.80	20.3	18.8	16.9	14.5	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.82	21.0	19.5	17.7	15.3	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.84	21.6	20.2	18.4	16.1	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.86	22.2	20.8	19.1	16.9	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.88	22.9	21.5	19.8	17.6	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.90	23.5	22.2	20.5	18.4	15.7	0.	0.	0.	0.	0.	0.	0.	0.
1.92	24.2	22.8	21.2	19.2	16.6	0.	0.	0.	0.	0.	0.	0.	0.
1.94	24.8	23.5	21.9	19.9	17.4	0.	0.	0.	0.	0.	0.	0.	0.
1.96	25.5	24.2	22.6	20.7	18.3	0.	0.	0.	0.	0.	0.	0.	0.
1.98	26.1	24.9	23.3	21.5	19.1	0.	0.	0.	0.	0.	0.	0.	0.
2.00	26.8	25.5	24.0	22.2	19.9	0.	0.	0.	0.	0.	0.	0.	0.
2.02	27.5	26.2	24.8	23.0	20.7	17.9	0.	0.	0.	0.	0.	0.	0.
2.04	28.2	26.9	25.5	23.7	21.6	18.8	0.	0.	0.	0.	0.	0.	0.
2.06	28.8	27.6	26.2	24.5	22.4	19.7	0.	0.	0.	0.	0.	0.	0.
2.08	29.5	28.3	26.9	25.2	23.2	20.6	0.	0.	0.	0.	0.	0.	0.
2.10	30.2	29.0	27.6	26.0	24.0	21.5	0.	0.	0.	0.	0.	0.	0.
2.12	30.9	29.7	28.4	26.7	24.8	22.4	19.3	0.	0.	0.	0.	0.	0.
2.14	31.6	30.5	29.1	27.5	25.6	23.2	20.3	0.	0.	0.	0.	0.	0.
2.16	32.3	31.2	29.8	28.3	26.4	24.1	21.2	0.	0.	0.	0.	0.	0.
2.18	33.0	31.9	30.6	29.0	27.2	24.9	22.2	0.	0.	0.	0.	0.	0.
2.20	33.7	32.6	31.3	29.8	28.0	25.8	23.1	0.	0.	0.	0.	0.	0.
2.22	34.5	33.4	32.1	30.6	28.8	26.6	24.0	0.	0.	0.	0.	0.	0.
2.24	35.2	34.1	32.8	31.3	29.6	27.5	24.9	21.7	0.	0.	0.	0.	0.
2.26	35.9	34.8	33.6	32.1	30.4	28.3	25.9	22.8	0.	0.	0.	0.	0.
2.28	36.7	35.6	34.3	32.9	31.2	29.2	26.8	23.8	0.	0.	0.	0.	0.
2.30	37.4	36.3	35.1	33.7	32.0	30.0	27.7	24.8	0.	0.	0.	0.	0.
2.32	38.2	37.1	35.9	34.5	32.8	30.9	28.6	25.7	0.	0.	0.	0.	0.
2.34	38.9	37.9	36.6	35.2	33.6	31.7	29.4	26.7	23.3	0.	0.	0.	0.
2.36	39.7	38.6	37.4	36.0	34.4	32.6	30.3	27.7	24.3	0.	0.	0.	0.
2.38	40.5	39.4	38.2	36.8	35.3	33.4	31.2	28.6	25.4	0.	0.	0.	0.

APPENDIX E. – Continued

Discharge in cfs for weir at Station 1430+08

Upstream water depth (Du) 2.40 – 3.28 Feet
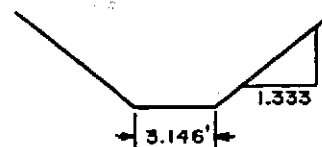
Downstream water depth (Dd) 1.3 – 2.5 Feet

Du	Dd – Downstream Water Depth												
	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50
2.40	41.2	40.2	39.0	37.6	36.1	34.3	32.1	29.6	26.5	0.	0.	0.	0.
2.42	42.0	41.0	39.8	38.5	36.9	35.1	33.0	30.5	27.5	0.	0.	0.	0.
2.44	42.8	41.8	40.6	39.3	37.7	36.0	33.9	31.5	28.5	0.	0.	0.	0.
2.46	43.6	42.6	41.4	40.1	38.6	36.8	34.8	32.4	29.5	26.0	0.	0.	0.
2.48	44.4	43.4	42.2	40.9	39.4	37.7	35.7	33.3	30.5	27.1	0.	0.	0.
2.50	45.2	44.2	43.0	41.7	40.3	38.6	36.6	34.3	31.5	28.2	0.	0.	0.
2.52	46.0	45.0	43.9	42.6	41.1	39.4	37.5	35.2	32.5	29.3	0.	0.	0.
2.54	46.8	45.8	44.7	43.4	42.0	40.3	38.4	36.2	33.5	30.4	0.	0.	0.
2.56	47.6	46.6	45.5	44.3	42.8	41.2	39.3	37.1	34.5	31.4	27.6	0.	0.
2.58	48.4	47.5	46.4	45.1	43.7	42.1	40.2	38.0	35.5	32.5	28.8	0.	0.
2.60	49.3	48.3	47.2	46.0	44.5	42.9	41.1	39.0	36.5	33.5	30.0	0.	0.
2.62	50.1	49.1	48.1	46.8	45.4	43.8	42.0	39.9	37.5	34.6	31.1	0.	0.
2.64	51.0	50.0	48.9	47.7	46.3	44.7	42.9	40.9	38.5	35.6	32.3	0.	0.
2.66	51.8	50.8	49.8	48.6	47.2	45.6	43.8	41.8	39.4	36.7	33.4	0.	0.
2.68	52.7	51.7	50.6	49.4	48.1	46.5	44.8	42.7	40.4	37.7	34.5	30.6	0.
2.70	53.5	52.6	51.5	50.3	49.0	47.4	45.7	43.7	41.4	38.7	35.6	31.8	0.
2.72	54.4	53.4	52.4	51.2	49.9	48.3	46.6	44.6	42.4	39.8	36.7	33.0	0.
2.74	55.3	54.3	53.3	52.1	50.8	49.2	47.5	45.6	43.4	40.8	37.8	34.2	0.
2.76	56.1	55.2	54.2	53.0	51.7	50.2	48.5	46.6	44.4	41.8	38.9	35.4	0.
2.78	57.0	56.1	55.1	53.9	52.6	51.1	49.4	47.5	45.4	42.9	40.0	36.5	32.4
2.80	57.9	57.0	56.0	54.8	53.5	52.0	50.4	48.5	46.4	43.9	41.1	37.7	33.7
2.82	58.8	57.9	56.9	55.7	54.4	53.0	51.3	49.5	47.3	44.9	42.1	38.9	34.9
2.84	59.7	58.8	57.8	56.6	55.3	53.9	52.3	50.4	48.3	46.0	43.2	40.0	36.2
2.86	60.6	59.7	58.7	57.6	56.3	54.8	53.2	51.4	49.3	47.0	44.3	41.2	37.4
2.88	61.5	60.6	59.6	58.5	57.2	55.8	54.2	52.4	50.3	48.0	45.4	42.3	38.6
2.90	62.5	61.6	60.6	59.4	58.2	56.7	55.2	53.4	51.4	49.1	46.5	43.4	39.9
2.92	63.4	62.5	61.5	60.4	59.1	57.7	56.1	54.4	52.4	50.1	47.5	44.6	41.1
2.94	64.3	63.4	62.4	61.3	60.1	58.7	57.1	55.3	53.4	51.1	48.6	45.7	42.3
2.96	65.3	64.4	63.4	62.3	61.0	59.6	58.1	56.3	54.4	52.2	49.7	46.8	43.5
2.98	66.2	65.3	64.3	63.2	62.0	60.6	59.1	57.3	55.4	53.2	50.8	47.9	44.7
3.00	67.2	66.3	65.3	64.2	63.0	61.6	60.1	58.4	56.4	54.3	51.8	49.1	45.8
3.02	68.1	67.2	66.3	65.2	63.9	62.6	61.1	59.4	57.5	55.3	52.9	50.2	47.0
3.04	69.1	68.2	67.2	66.1	64.9	63.6	62.1	60.4	58.5	56.4	54.0	51.3	48.2
3.06	70.1	69.2	68.2	67.1	65.9	64.6	63.1	61.4	59.5	57.4	55.1	52.4	49.4
3.08	71.0	70.2	69.2	68.1	66.9	65.6	64.1	62.4	60.6	58.5	56.2	53.5	50.5
3.10	72.0	71.1	70.2	69.1	67.9	66.6	65.1	63.5	61.6	59.6	57.3	54.7	51.7
3.12	73.0	72.1	71.2	70.1	68.9	67.6	66.1	64.5	62.7	60.6	58.4	55.8	52.9
3.14	74.0	73.1	72.2	71.1	69.9	68.6	67.2	65.5	63.7	61.7	59.5	56.9	54.0
3.16	75.0	74.1	73.2	72.1	70.9	69.6	68.2	66.6	64.8	62.8	60.6	58.1	55.2
3.18	76.0	75.1	74.2	73.1	72.0	70.7	69.2	67.6	65.8	63.9	61.7	59.2	56.4
3.20	77.0	76.2	75.2	74.2	73.0	71.7	70.3	68.7	66.9	65.0	62.8	60.3	57.6
3.22	78.0	77.2	76.2	75.2	74.0	72.7	71.3	69.7	68.0	66.0	63.9	61.5	58.7
3.24	79.1	78.2	77.3	76.2	75.1	73.8	72.4	70.8	69.1	67.1	65.0	62.6	59.9
3.26	80.1	79.3	78.3	77.3	76.1	74.8	73.4	71.9	70.1	68.2	66.1	63.7	61.1
3.28	81.1	80.3	79.4	78.3	77.2	75.9	74.5	73.0	71.2	69.3	67.2	64.9	62.2

Discharge in cfs for weir at Station 1459+9G

Upstream water depth (Du) 0.50 – 1.48 Feet

Downstream water depth (Dd) 0.0 – 1.2 Feet

1.333

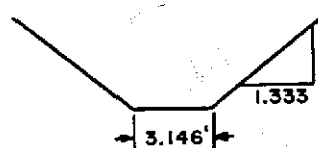3.146'

Du	Dd – Downstream Water Depth												
	0.	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00	1.10	1.20
.50	4.6	4.5	4.3	4.0	3.2	0.	0.	0.	0.	0.	0.	0.	0.
.52	4.8	4.8	4.6	4.3	3.6	0.	0.	0.	0.	0.	0.	0.	0.
.54	5.1	5.0	4.9	4.6	3.9	0.	0.	0.	0.	0.	0.	0.	0.
.56	5.4	5.3	5.2	4.9	4.3	3.1	0.	0.	0.	0.	0.	0.	0.
.58	5.7	5.6	5.5	5.2	4.7	3.6	0.	0.	0.	0.	0.	0.	0.
.60	6.1	6.0	5.8	5.6	5.0	4.0	0.	0.	0.	0.	0.	0.	0.
.62	6.4	6.3	6.2	5.9	5.4	4.5	0.	0.	0.	0.	0.	0.	0.
.64	6.7	6.6	6.5	6.3	5.8	4.9	0.	0.	0.	0.	0.	0.	0.
.66	7.1	7.0	6.9	6.6	6.2	5.3	0.	0.	0.	0.	0.	0.	0.
.68	7.5	7.4	7.3	7.0	6.5	5.8	4.4	0.	0.	0.	0.	0.	0.
.70	7.9	7.7	7.6	7.4	7.0	6.2	4.9	0.	0.	0.	0.	0.	0.
.72	8.2	8.1	8.0	7.8	7.4	6.7	5.5	0.	0.	0.	0.	0.	0.
.74	8.6	8.5	8.4	8.2	7.8	7.1	6.0	0.	0.	0.	0.	0.	0.
.76	9.1	8.9	8.8	8.6	8.2	7.6	6.5	0.	0.	0.	0.	0.	0.
.78	9.5	9.4	9.3	9.0	8.6	8.0	7.0	5.2	0.	0.	0.	0.	0.
.80	9.9	9.8	9.7	9.5	9.1	8.5	7.5	5.9	0.	0.	0.	0.	0.
.82	10.4	10.2	10.1	9.9	9.6	9.0	8.1	6.6	0.	0.	0.	0.	0.
.84	10.8	10.7	10.6	10.4	10.0	9.5	8.6	7.2	0.	0.	0.	0.	0.
.86	11.3	11.2	11.1	10.9	10.5	9.9	9.1	7.8	0.	0.	0.	0.	0.
.88	11.8	11.6	11.5	11.3	11.0	10.4	9.6	8.4	0.	0.	0.	0.	0.
.90	12.3	12.1	12.0	11.8	11.5	11.0	10.2	9.0	7.0	0.	0.	0.	0.
.92	12.8	12.6	12.5	12.3	12.0	11.5	10.7	9.6	7.7	0.	0.	0.	0.
.94	13.3	13.1	13.0	12.9	12.5	12.0	11.3	10.2	8.5	0.	0.	0.	0.
.96	13.8	13.7	13.6	13.4	13.1	12.6	11.8	10.8	9.2	0.	0.	0.	0.
.98	14.4	14.2	14.1	13.9	13.6	13.1	12.4	11.4	9.9	0.	0.	0.	0.
1.00	14.9	14.7	14.6	14.5	14.1	13.7	13.0	12.0	10.5	0.	0.	0.	0.
1.02	15.5	15.3	15.2	15.0	14.7	14.2	13.6	12.6	11.2	9.0	0.	0.	0.
1.04	16.1	15.9	15.8	15.6	15.3	14.8	14.2	13.2	11.9	9.8	0.	0.	0.
1.06	16.6	16.4	16.4	16.2	15.9	15.4	14.8	13.9	12.6	10.6	0.	0.	0.
1.08	17.2	17.0	16.9	16.8	16.5	16.0	15.4	14.5	13.2	11.4	0.	0.	0.
1.10	17.8	17.6	17.5	17.4	17.1	16.6	16.0	15.1	13.9	12.2	0.	0.	0.
1.12	18.5	18.2	18.2	18.0	17.7	17.3	16.6	15.8	14.6	12.9	10.4	0.	0.
1.14	19.1	18.9	18.8	18.6	18.3	17.9	17.3	16.4	15.3	13.7	11.3	0.	0.
1.16	19.7	19.5	19.4	19.2	19.0	18.5	17.9	17.1	16.0	14.5	12.2	0.	0.
1.18	20.4	20.1	20.1	19.9	19.6	19.2	18.6	17.8	16.7	15.2	13.1	0.	0.
1.20	21.0	20.8	20.7	20.5	20.3	19.9	19.3	18.5	17.4	16.0	13.9	0.	0.
1.22	21.7	21.4	21.4	21.2	20.9	20.5	20.0	19.2	18.1	16.7	14.8	0.	0.
1.24	22.4	22.1	22.1	21.9	21.6	21.2	20.7	19.9	18.9	17.5	15.6	12.9	0.
1.26	23.1	22.8	22.7	22.6	22.3	21.9	21.4	20.6	19.6	18.3	16.5	13.9	0.
1.28	23.8	23.5	23.4	23.3	23.0	22.6	22.1	21.3	20.4	19.1	17.3	14.8	0.
1.30	24.5	24.2	24.2	24.0	23.7	23.3	22.8	22.1	21.1	19.9	18.2	15.8	0.
1.32	25.3	24.9	24.9	24.7	24.5	24.1	23.5	22.8	21.9	20.6	19.0	16.7	0.
1.34	26.0	25.7	25.6	25.5	25.2	24.8	24.3	23.6	22.7	21.4	19.8	17.7	14.5
1.36	26.7	26.4	26.4	26.2	26.0	25.6	25.0	24.3	23.4	22.2	20.7	18.6	15.6
1.38	27.5	27.2	27.1	27.0	26.7	26.3	25.8	25.1	24.2	23.1	21.5	19.5	16.7
1.40	28.3	27.9	27.9	27.7	27.5	27.1	26.6	25.9	25.0	23.9	22.4	20.4	17.7
1.42	29.1	28.7	28.7	28.5	28.3	27.9	27.4	26.7	25.8	24.7	23.3	21.4	18.8
1.44	29.9	29.5	29.5	29.3	29.1	28.7	28.2	27.5	26.7	25.6	24.1	22.3	19.8
1.46	30.7	30.3	30.3	30.1	29.9	29.5	29.0	28.3	27.5	26.4	25.0	23.2	20.8
1.48	31.5	31.1	31.1	30.9	30.7	30.3	29.8	29.2	28.3	27.3	25.9	24.1	21.8

Discharge in cfs for weir at Station 1459+90

Upstream water depth (Du) 1.50 - 2.48 Feet

Downstream water depth (Dd) 0.0 - 1.2 Feet

| Du	| 0.	| .10	| .20	| .30	| .40	| .50	| .60	| .70	| .80	| .90	1.00	1.10	1.20
						Dd – Downstream Water Depth							
1.50	32.3	31.9	31.9	31.8	31.5	31.1	30.7	30.0	29.2	28.1	26.8	25.1	22.8
1.52	33.2	32.8	32.7	32.6	32.3	32.0	31.5	30.9	30.0	29.0	27.7	26.0	23.8
1.54	34.0	33.6	33.6	33.4	33.2	32.8	32.4	31.7	30.9	29.9	28.6	27.0	24.8
1.56	34.9	34.5	34.4	34.3	34.1	33.7	33.2	32.6	31.8	30.8	29.5	27.9	25.8
1.58	35.8	35.3	35.3	35.2	34.9	34.6	34.1	33.5	32.7	31.7	30.4	28.9	26.8
1.60	36.7	36.2	36.2	36.0	35.8	35.5	35.0	34.4	33.6	32.6	31.4	29.8	27.9
1.62	37.6	37.1	37.1	36.9	36.7	36.4	35.9	35.3	34.5	33.5	32.3	30.8	28.9
1.64	38.5	38.0	38.0	37.8	37.6	37.3	36.8	36.2	35.4	34.5	33.3	31.8	29.9
1.66	39.4	38.9	38.9	38.7	38.5	38.2	37.7	37.1	36.4	35.4	34.2	32.7	30.9
1.68	40.3	39.8	39.8	39.7	39.4	39.1	38.7	38.1	37.3	36.4	35.2	33.7	31.9
1.70	41.3	40.8	40.7	40.6	40.4	40.0	39.6	39.0	38.3	37.3	36.2	34.7	33.0
1.72	42.2	41.7	41.7	41.6	41.3	41.0	40.5	40.0	39.2	38.3	37.2	35.7	34.0
1.74	43.2	42.7	42.6	42.5	42.3	42.0	41.5	40.9	40.2	39.3	38.2	36.8	35.1
1.76	44.2	43.6	43.6	43.5	43.3	42.9	42.5	41.9	41.2	40.3	39.2	37.8	36.1
1.78	45.2	44.6	44.6	44.5	44.2	43.9	43.5	42.9	42.2	41.3	40.2	38.8	37.2
1.80	46.2	45.6	45.6	45.5	45.2	44.9	44.5	43.9	44.2	43.3	42.2	40.9	39.3
1.82	47.2	46.6	46.6	46.5	47.3	45.9	45.5	45.9	45.2	44.4	43.3	42.0	40.4
1.84	48.2	47.6	47.6	47.5	47.3	46.9	46.5	45.9	45.2	44.4	43.3	42.0	40.4
1.86	49.2	48.6	48.6	48.5	48.3	48.0	47.5	47.0	46.3	45.4	44.3	43.1	41.5
1.88	50.3	49.7	49.6	49.5	49.3	49.0	48.6	48.0	47.3	46.5	45.4	44.1	42.6
1.90	51.3	50.7	50.7	50.6	50.4	50.1	49.6	49.1	48.4	47.5	46.5	45.2	43.7
1.92	52.4	51.8	51.8	51.6	51.4	51.1	50.7	50.1	49.5	48.6	47.6	46.3	44.8
1.94	53.5	52.9	52.8	52.7	52.5	52.2	51.8	51.2	50.5	49.7	48.7	47.4	46.0
1.96	54.6	53.9	53.9	53.8	53.6	53.3	52.9	52.3	51.6	50.8	49.8	48.6	47.1
1.98	55.7	55.0	55.0	54.9	54.7	54.4	54.0	53.4	52.7	51.9	50.9	49.7	48.3
2.00	56.8	56.1	56.1	56.0	55.8	55.5	55.1	54.5	53.9	53.0	52.0	50.8	49.4
2.02	57.9	57.2	57.2	57.1	56.9	56.6	56.2	55.6	55.0	54.2	53.2	52.0	50.6
2.04	59.1	58.4	58.3	58.2	58.0	57.7	57.3	56.8	56.1	55.3	54.3	53.2	51.8
2.06	60.2	59.5	59.5	59.4	59.2	58.9	58.5	57.9	57.3	56.5	55.5	54.3	52.9
2.08	61.4	60.6	60.6	60.5	60.3	60.0	59.6	59.1	58.4	57.6	56.7	55.5	54.1
2.10	62.5	61.8	61.8	61.7	61.5	61.2	60.8	60.2	59.6	58.8	57.8	56.7	55.3
2.12	63.7	63.0	62.9	62.8	62.6	62.3	61.9	61.4	60.8	60.0	59.0	57.9	56.6
2.14	64.9	64.1	64.1	64.0	63.8	63.5	63.1	62.6	62.0	61.2	60.2	59.1	57.8
2.16	66.1	65.3	65.3	65.2	65.0	64.7	64.3	63.8	63.2	62.4	61.5	60.3	59.0
2.18	67.3	66.5	66.5	66.4	66.2	65.9	65.5	65.0	64.4	63.6	62.7	61.6	60.3
2.20	68.6	67.7	67.7	67.6	67.4	67.1	66.8	66.2	65.6	64.8	63.9	62.8	61.5
2.22	69.8	69.0	68.9	68.8	68.7	68.4	68.0	67.5	66.8	66.1	65.2	64.1	62.8
2.24	71.0	70.2	70.2	70.1	69.9	69.6	69.2	68.7	68.1	67.3	66.4	65.3	64.1
2.26	72.3	71.4	71.4	71.3	71.1	70.9	70.5	70.0	69.4	68.6	67.7	66.6	65.3
2.28	73.6	72.7	72.7	72.6	72.4	72.1	71.7	71.2	70.6	69.9	69.0	67.9	66.6
2.30	74.9	74.0	74.0	73.9	73.7	73.4	73.0	72.5	71.9	71.2	70.3	69.2	67.9
2.32	76.2	75.2	75.2	75.1	75.0	74.7	74.3	73.8	73.2	72.4	71.6	70.5	69.3
2.34	77.5	76.5	76.5	76.4	76.2	76.0	75.6	75.1	74.5	73.8	72.9	71.8	70.6
2.36	78.8	77.8	77.8	77.7	77.6	77.3	76.9	76.4	75.8	75.1	74.2	73.1	71.9
2.38	80.1	79.1	79.1	79.0	78.9	78.6	78.2	77.7	77.1	76.4	75.5	74.5	73.3
2.40	81.5	80.5	80.5	80.4	80.2	79.9	79.5	79.1	78.5	77.7	76.9	75.8	74.6
2.42	82.8	81.8	81.8	81.7	81.5	81.3	80.9	80.4	79.8	79.1	78.2	77.2	76.0
2.44	84.2	83.2	83.1	83.1	82.9	82.6	82.2	81.8	81.2	80.4	79.6	78.6	77.4
2.46	85.5	84.5	84.5	84.4	84.2	84.0	83.6	83.1	82.5	81.8	81.0	79.9	78.8
2.48	86.9	85.9	85.9	85.8	85.6	85.3	85.0	84.5	83.9	83.2	82.3	81.3	80.2

Discharge in cfs for weir at Station 1459+90

Upstream water depth (Du) 1.40 - 1.89 Feet

Downstream water depth (Dd) 1.3 - 1.9 Feet
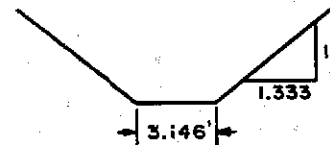
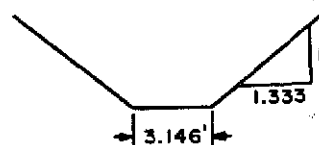| Du	Dd - Downstream Water Depth												
	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90
1.40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.41	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.43	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.44	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.45	16.8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.46	17.4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.47	18.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.48	18.6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.49	19.2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.50	19.8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.51	20.3	18.3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.52	20.9	19.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.53	21.5	19.6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.54	22.0	20.2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.55	22.6	20.8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.56	23.1	21.4	19.3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.57	23.7	22.0	20.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.58	24.2	22.6	20.6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.59	24.8	23.2	21.2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.60	25.3	23.7	21.9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.61	25.9	24.3	22.5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.62	26.4	24.9	23.1	21.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.63	27.0	25.5	23.7	21.6	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.64	27.5	26.0	24.3	22.3	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.65	28.0	26.6	24.9	23.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.66	28.6	27.2	25.5	23.6	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.67	29.1	27.7	26.1	24.2	22.0	0.	0.	0.	0.	0.	0.	0.	0.
1.68	29.7	28.3	26.7	24.9	22.7	0.	0.	0.	0.	0.	0.	0.	0.
1.69	30.2	28.9	27.3	25.5	23.4	0.	0.	0.	0.	0.	0.	0.	0.
1.70	30.8	29.4	27.9	26.1	24.1	0.	0.	0.	0.	0.	0.	0.	0.
1.71	31.3	30.0	28.5	26.8	24.7	0.	0.	0.	0.	0.	0.	0.	0.
1.72	31.8	30.6	29.1	27.4	25.4	0.	0.	0.	0.	0.	0.	0.	0.
1.73	32.4	31.1	29.7	28.0	26.1	23.8	0.	0.	0.	0.	0.	0.	0.
1.74	32.9	31.7	30.3	28.6	26.7	24.5	0.	0.	0.	0.	0.	0.	0.
1.75	33.5	32.2	30.8	29.2	27.4	25.2	0.	0.	0.	0.	0.	0.	0.
1.76	34.0	32.8	31.4	29.9	28.0	25.9	0.	0.	0.	0.	0.	0.	0.
1.77	34.6	33.4	32.0	30.5	28.7	26.6	0.	0.	0.	0.	0.	0.	0.
1.78	35.1	33.9	32.6	31.1	29.3	27.3	24.8	0.	0.	0.	0.	0.	0.
1.79	35.7	34.5	33.2	31.7	30.0	28.0	25.6	0.	0.	0.	0.	0.	0.
1.80	36.3	35.1	33.8	32.3	30.6	28.6	26.3	0.	0.	0.	0.	0.	0.
1.81	36.8	35.6	34.4	32.9	31.2	29.3	27.1	0.	0.	0.	0.	0.	0.
1.82	37.4	36.2	34.9	33.5	31.9	30.0	27.8	0.	0.	0.	0.	0.	0.
1.83	37.9	36.8	35.5	34.1	32.5	30.6	28.5	0.	0.	0.	0.	0.	0.
1.84	38.5	37.4	36.1	34.7	33.1	31.3	29.2	26.7	0.	0.	0.	0.	0.
1.85	39.0	37.9	36.7	35.3	33.7	32.0	29.9	27.5	0.	0.	0.	0.	0.
1.86	39.6	38.5	37.3	35.9	34.4	32.6	30.6	28.3	0.	0.	0.	0.	0.
1.87	40.2	39.1	37.9	36.5	35.0	33.3	31.3	29.0	0.	0.	0.	0.	0.
1.88	40.7	39.7	38.5	37.1	35.6	33.9	32.0	29.8	0.	0.	0.	0.	0.
1.89	41.3	40.2	39.1	37.7	36.3	34.6	32.7	30.5	27.9	0.	0.	0.	0.

APPENDIX F. - Continued

Discharge in cfs for weir at Station 1459+90

Upstream water depth (Du) 1.90 - 2.39 Feet

Downstream water depth (Dd) 1.3 - 1.9 Feet

1.333

3.146'

1

Du	Dd - Downstream Water Depth												
	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90
1.90	41.9	40.8	39.6	38.3	36.9	35.2	33.4	31.2	28.7	0.	0.	0.	0.
1.91	42.5	41.4	40.2	38.9	37.5	35.9	34.1	31.9	29.5	0.	0.	0.	0.
1.92	43.0	42.0	40.8	39.6	38.1	36.5	34.7	32.7	30.3	0.	0.	0.	0.
1.93	43.6	42.6	41.4	40.2	38.8	37.2	35.4	33.4	31.0	0.	0.	0.	0.
1.94	44.2	43.2	42.0	40.8	39.4	37.8	36.1	34.1	31.8	0.	0.	0.	0.
1.95	44.8	43.7	42.6	41.4	40.0	38.5	36.8	34.8	32.5	29.9	0.	0.	0.
1.96	45.3	44.3	43.2	42.0	40.6	39.1	37.4	35.5	33.3	30.7	0.	0.	0.
1.97	45.9	44.9	43.8	42.6	41.3	39.8	38.1	36.2	34.0	31.5	0.	0.	0.
1.98	46.5	45.5	44.4	43.2	41.9	40.4	38.8	36.9	34.8	32.3	0.	0.	0.
1.99	47.1	46.1	45.0	43.8	42.5	41.1	39.4	37.6	35.5	33.1	0.	0.	0.
2.00	47.7	46.7	45.6	44.5	43.2	41.7	40.1	38.3	36.2	33.9	0.	0.	0.
2.01	48.3	47.3	46.3	45.1	43.8	42.4	40.8	39.0	37.0	34.7	32.0	0.	0.
2.02	48.9	47.9	46.9	45.7	44.4	43.0	41.4	39.7	37.7	35.4	32.8	0.	0.
2.03	49.5	48.5	47.5	46.3	45.1	43.7	42.1	40.4	38.4	36.2	33.6	0.	0.
2.04	50.1	49.1	48.1	46.9	45.7	44.3	42.8	41.1	39.1	37.0	34.4	0.	0.
2.05	50.7	49.7	48.7	47.6	46.3	45.0	43.4	41.8	39.9	37.7	35.2	0.	0.
2.06	51.3	50.3	49.3	48.2	47.0	45.6	44.1	42.4	40.6	38.5	36.0	33.2	0.
2.07	51.9	51.0	49.9	48.8	47.6	46.3	44.8	43.1	41.3	39.2	36.8	34.1	0.
2.08	52.5	51.6	50.6	49.5	48.2	46.9	45.4	43.8	42.0	40.0	37.6	34.9	0.
2.09	53.1	52.2	51.2	50.1	48.9	47.6	46.1	44.5	42.7	40.7	38.4	35.8	0.
2.10	53.7	52.8	51.8	50.7	49.5	48.2	46.8	45.2	43.4	41.4	39.2	36.6	0.
2.11	54.3	53.4	52.4	51.4	50.2	48.9	47.5	45.9	44.1	42.2	40.0	37.5	0.
2.12	55.0	54.1	53.1	52.0	50.8	49.5	48.1	46.6	44.8	42.9	40.8	38.3	35.4
2.13	55.6	54.7	53.7	52.6	51.5	50.2	48.8	47.3	45.6	43.7	41.5	39.1	36.3
2.14	56.2	55.3	54.3	53.3	52.1	50.9	49.5	47.9	46.3	44.4	42.3	39.9	37.2
2.15	56.8	55.9	55.0	53.9	52.8	51.5	50.1	48.6	47.0	45.1	43.1	40.7	38.0
2.16	57.4	56.6	55.6	54.6	53.4	52.2	50.8	49.3	47.7	45.9	43.8	41.5	38.9
2.17	58.1	57.2	56.2	55.2	54.1	52.8	51.5	50.0	48.4	46.6	44.6	42.3	39.7
2.18	58.7	57.8	56.9	55.9	54.7	53.5	52.2	50.7	49.1	47.3	45.3	43.1	40.6
2.19	59.3	58.5	57.5	56.5	55.4	54.2	52.9	51.4	49.8	48.0	46.1	43.9	41.4
2.20	60.0	59.1	58.2	57.2	56.1	54.8	53.5	52.1	50.5	48.8	46.8	44.7	42.2
2.21	60.6	59.8	58.8	57.8	56.7	55.5	54.2	52.8	51.2	49.5	47.6	45.5	43.1
2.22	61.3	60.4	59.5	58.5	57.4	56.2	54.9	53.5	51.9	50.2	48.4	46.3	43.9
2.23	61.9	61.0	60.1	59.1	58.0	56.9	55.6	54.2	52.7	51.0	49.1	47.0	44.7
2.24	62.5	61.7	60.8	59.8	58.7	57.5	56.3	54.9	53.4	51.7	49.9	47.8	45.5
2.25	63.2	62.4	61.4	60.5	59.4	58.2	57.0	55.6	54.1	52.4	50.6	48.6	46.3
2.26	63.8	63.0	62.1	61.1	60.1	58.9	57.6	56.3	54.8	53.2	51.4	49.4	47.1
2.27	64.5	63.7	62.8	61.8	60.7	59.6	58.3	57.0	55.5	53.9	52.1	50.1	48.0
2.28	65.2	64.3	63.4	62.5	61.4	60.3	59.0	57.7	56.2	54.6	52.9	50.9	48.8
2.29	65.8	65.0	64.1	63.1	62.1	60.9	59.7	58.4	56.9	55.3	53.6	51.7	49.6
2.30	66.5	65.6	64.8	63.8	62.8	61.6	60.4	59.1	57.7	56.1	54.4	52.5	50.4
2.31	67.1	66.3	65.4	64.5	63.4	62.3	61.1	59.8	58.4	56.8	55.1	53.2	51.2
2.32	67.8	67.0	66.1	65.2	64.1	63.0	61.8	60.5	59.1	57.6	55.9	54.0	52.0
2.33	68.5	67.7	66.8	65.8	64.8	63.7	62.5	61.2	59.8	58.3	56.6	54.8	52.8
2.34	69.1	68.3	67.5	66.5	65.5	64.4	63.2	61.9	60.5	59.0	57.4	55.5	53.6
2.35	69.8	69.0	68.1	67.2	66.2	65.1	63.9	62.6	61.3	59.8	58.1	56.3	54.3
2.36	70.5	69.7	68.8	67.9	66.9	65.8	64.6	63.4	62.0	60.5	58.9	57.1	55.1
2.37	71.2	70.4	69.5	68.6	67.6	66.5	65.3	64.1	62.7	61.2	59.6	57.9	55.9
2.38	71.8	71.1	70.2	69.3	68.3	67.2	66.1	64.8	63.4	62.0	60.4	58.6	56.7
2.39	72.5	71.7	70.9	70.0	69.0	67.9	66.8	65.5	64.2	62.7	61.1	59.4	57.5

GPO 646-090

CONVERSION FACTORS--BRITISH TO METRIC UNITS OF MEASUREMENT

The following conversion factors adopted by the Bureau of Reclamation are those published by the American Society for Testing and Materials (ASTM Metric Practice Guide, January 1964) except that additional factors (*) commonly used in the Bureau have been added. Further discussion of definitions of quantities and units is given on pages 10-11 of the ASTM Metric Practice Guide.

The metric units and conversion factors adopted by the ASTM are based on the "International System of Units" (designated SI for Systeme International d'Unites), fixed by the International Committee for Weights and Measures; this system is also known as the Giorgi or MKSA (meter-kilogram (mass)-second-ampere) system. This system has been adopted by the International Organization for Standardization in ISO Recommendation R-31.

The metric technical unit of force is the kilogram-force; this is the force which, when applied to a body having a mass of 1 kg, gives it an acceleration of 9.80665 m/sec/sec, the standard acceleration of free fall toward the earth's center for sea level at 45 deg latitude. The metric unit of force in SI units is the newton (N), which is defined as that force which, when applied to a body having a mass of 1 kg, gives it an acceleration of 1 m/sec/sec. These units must be distinguished from the (inconstant) local weight of a body having a mass of 1 kg; that is, the weight of a body is that force with which a body is attracted to the earth and is equal to the mass of a body multiplied by the acceleration due to gravity. However, because it is general practice to use "pound" rather than the technically correct term "pound-force," the term "kilogram" (or derived mass unit) has been used in this guide instead of "kilogram-force" in expressing the conversion factors for forces. The newton unit of force will find increasing use, and is essential in SI units.

Table I

QUANTITIES AND UNITS OF SPACE

Multiply	By	To obtain

LENGTH

Multiply	By	To obtain
Mil	25.4 (exactly)	Micron
Inches	25.4 (exactly)	Millimeters
	2.54 (exactly)*	Centimeters
Feet	30.48 (exactly)	Centimeters
	0.3048 (exactly)*	Meters
	0.0003048 (exactly)*	Kilometers
Yards	0.9144 (exactly)	Meters
Miles (statute)	1,609.344 (exactly)*	Meters
	1.609344 (exactly)	Kilometers

AREA

Multiply	By	To obtain
Square inches	6.4516 (exactly)	Square centimeters
Square feet	929.03*	Square centimeters
	0.092903	Square meters
Square yards	0.836127	Square meters
Acres	0.40469*	Hectares
	4,046.9*	Square meters
	0.0040469*	Square kilometers
Square miles	2.58999	Square kilometers

VOLUME

Multiply	By	To obtain
Cubic inches	16.3871	Cubic centimeters
Cubic feet	0.0283168	Cubic meters
Cubic yards	0.764555	Cubic meters

CAPACITY

Multiply	By	To obtain
Fluid ounces (U.S.)	29.5737	Cubic centimeters
	29.5729	Milliliters
Liquid pints (U.S.)	0.473179	Cubic decimeters
	0.473166	Liters
Quarts (U.S.)	946.358*	Cubic centimeters
	0.946331*	Liters
Gallons (U.S.)	3,785.43*	Cubic centimeters
	3.78543	Cubic decimeters
	3.78533	Liters
	0.00378543*	Cubic meters
Gallons (U.K.)	4.54609	Cubic decimeters
	4.54596	Liters
Cubic feet	28.3160	Liters
Cubic yards	764.55*	Liters
Acre-feet	1,233.5*	Cubic meters
	1,233,500*	Liters

Table II

QUANTITIES AND UNITS OF MECHANICS

MASS

Multiply	By	To obtain
Grains (1/7,000 lb)	64.79891 (exactly)	Milligrams
Troy ounces (480 grains)	31.1035	Grams
Ounces (avdp)	28.3495	Grams
Pounds (avdp)	0.4535924 (exactly)	Kilograms
Short tons (2,000 lb)	907.185	Kilograms
	907.185	Metric tons
Long tons (2,240 lb)	1,016.05	Kilograms

FORCE/AREA

Multiply	By	To obtain
Pounds per square inch	0.070307	Kilograms per square centimeter
	0.689476	Newtons per square centimeter
Pounds per square foot	4.88243	Kilograms per square meter
	47.8803	Newtons per square meter

MASS/VOLUME (DENSITY)

Multiply	By	To obtain
Ounces per cubic inch	1.72999	Grams per cubic centimeter
Pounds per cubic foot	16.0185	Kilograms per cubic meter
	0.0160185	Grams per cubic centimeter
Tons (long) per cubic yard	1.32894	Grams per cubic centimeter

MASS/CAPACITY

Multiply	By	To obtain
Ounces per gallon (U.S.)	7.4893	Grams per liter
Ounces per gallon (U.K.)	6.2362	Grams per liter
Pounds per gallon (U.S.)	119.829	Grams per liter
Pounds per gallon (U.K.)	99.779	Grams per liter

BENDING MOMENT OR TORQUE

Multiply	By	To obtain
Inch-pounds	0.011521	Meter-kilograms
	1.12985×10^6	Centimeter-dynes
Foot-pounds	0.138255	Meter-kilograms
	1.35582×10^7	Centimeter-dynes
Foot-pounds per inch	5.4431	Centimeter-kilograms per centimeter
Ounce-inches	72.008	Gram-centimeters

VELOCITY

Multiply	By	To obtain
Feet per second	30.48 (exactly)	Centimeters per second
	0.3048 (exactly)	Meters per second
Feet per year	0.965873×10^{-8}	Centimeters per second
Miles per hour	1.609344 (exactly)	Kilometers per hour
	0.44704 (exactly)	Meters per second

ACCELERATION*

Multiply	By	To obtain
Feet per second^2	0.3048*	Meters per second^2

FLOW

Multiply	By	To obtain
Cubic feet per second (second-feet)	0.028317*	Cubic meters per second
Cubic feet per minute	0.4719	Liters per second
Gallons (U.S.) per minute	0.06309	Liters per second

FORCE*

Multiply	By	To obtain
Pounds	0.453692*	Kilograms
	4.4482*	Newtons
	4.4482×10^{-5}*	Dynes

WORK AND ENERGY*

Multiply	By	To obtain
British thermal units (Btu)	0.252*	Kilogram calories
	1,055.06	Joules
Btu per pound	2.328 (exactly)	Joules per gram
Foot-pounds	1.35582*	Joules

POWER

Multiply	By	To obtain
Horsepower	745.700	Watts
Btu per hour	0.293071	Watts
Foot-pounds per second	1.35582	Watts

HEAT TRANSFER

Multiply	By	To obtain
Btu in./hr ft^2 deg F (k, thermal conductivity)	1.442	Milliwatts/cm deg C
	1.240.	Kg cal/hr m deg C
	1.4880*	Kg cal/hr m^2 deg C
Btu/hr ft^2 deg F	0.568	Milliwatts/cm^2 deg C
Btu/hr ft^2 deg F (C, thermal conductance)	4.882	Kg cal/hr m^2 deg C
Deg F hr ft^2/Btu (R, thermal resistance)	1.761	Deg C cm^2/milliwatt
Btu/lb deg F (c, heat capacity)	4.1868	J/g deg C
Btu/lb deg F	1.000*	Cal/gram deg C
Ft^2/hr (thermal diffusivity)	0.2581	Cm^2/sec
	0.09290*	M^2/hr

WATER VAPOR TRANSMISSION

Multiply	By	To obtain
Grains/hr ft^2 (water vapor transmission)	16.7	Grams/24 hr m^2
Perms (permeance)	0.659	Metric perms
Perm-inches (permeability)	1.67	Metric perm-centimeters

Table III

OTHER QUANTITIES AND UNITS

Multiply	By	To obtain
Cubic feet per square foot per day (seepage)	304.8*	Liters per square meter per day
Pound-seconds per square foot (viscosity)	4.8824*	Kilogram second per square meter
Square feet per second (viscosity)*	0.092903.	Square meters per second (change)*
Fahrenheit degrees (change)*	5/9 exactly	Celsius or Kelvin degrees (change)*
Volts per mil	0.03937.	Kilovolts per millimeter
Lumens per square foot (foot-candles)	10.764.	Lumens per square meter
Ohm-circular mils per foot	0.001662	Ohm-square millimeters per meter
Millicuries per cubic foot	35.3147*	Millicuries per cubic meter
Milliamps per square foot	10.7639*	Milliamps per square meter
Gallons per square yard	4.527219*	Liters per square meter
Pounds per inch	0.17858*	Kilograms per centimeter

ABSTRACT

Three differently shaped trapezoidal weirs were calibrated in the hydraulic laboratory for free flow and submerged flow canal discharge measurements in field canals of 50- and 90-cfs designed capacity. The 3 weirs were calibrated in the same test facility using model scales of 1:5, 1:2.67, and 1:2.33. In each case the canal bottom upstream from the weir was flush with the weir invert and the downstream canal bottom had a 1.5- to 3-ft vertical drop at the weir. An electronic digital computer was used to make a least squares fit of the calibration data to a curve. Second degree polynomial equations were derived describing free flow conditions and general conical equations describing submerged flow conditions. The computer was used to obtain weir discharge tables and information for weir discharge graphs for submerged conditions. Discharge tables and graphs for each weir and drawings and photographs of model and prototype weir structures are included in the report.

Hyd-583
Zeigler, E R
HYDRAULIC MODEL CALIBRATION AND COMPUTER ANALYSIS OF TRAPEZOIDAL TIMBER
CONTROL CHECK WEIRS--FARWELL MAIN CANAL, NEBRASKA--OCCS PROGRAM. Bur
Reclam Lab Rep Hyd-583, Hydraul Br, Aug 1968. Bureau of Reclamation,
Denver, 10 p, 17 fig, 6 tab, 5 appendl

DESCRIPTORS--/ open channel flow/ turbulent flow/ *sharp crested weirs/
subcritical flow/ hydraulic models/ model tests/ *discharge measurement/
*submerged weirs/ curve fitting/ calibrations/ check structures/ weirs
IDENTIFIERS--/ *trapezoidal weirs/ least squares method